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Japan

INTERNATIONAL SYMPOSIUM ON REMOTE SENSING: JERS-1

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SCIENCE & TECHNOLOGY

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Nov. 22(FRI), 1991

Morning Session

Chairman: Dr. Nobuhiko Kodaira (Technical Adviser, RESTEC)

Afternoon Session

Chairman: Mr. Toru Udo (Executive Director, ERSDAC)

Coffee break

17:20 Adjourn
Mr. Yoshio Yorimizu
:Executive Senior Managing Director, RESTEC

Keynote Address

Professor emeritus,
University of Tokyo
Shigebumi Saito

Introduction

Japanese Earth Resources Satellite -1 (JERS-1) equipped with new sensors such as a Synthetic Aperture Radar (SAR) and an Optical Sensor (OPS) is scheduled to be launched in February, next year as a Japanese earth observation Satellite following Marine Observation Satellites, MOS-1 and MOS-1b.

JERS-1 aims at resources exploration as well as observation used for land survey, agriculture, forestry, fishery, environment protection, disaster prevention, coastal monitoring, and so on by observing all over the land of the world. JERS-1 has distinctive sensors, attracting worldwide attention, and it is very useful for users since it can observe the entire earth through a data recorder.

JERS-1 was cooperatively developed by Science and Technology Agency (STA) / National Space Development Agency of Japan (NASDA) and Ministry of International Trade and Industry (MITI). STA / NASDA and MITI were in charge of developing the satellite bus and observation equipment (mission equipment) respectively. After developed them by coordinating each other, the satellite system was transferred to the launch site in Tanegashima at the end of last month. Fig.1 shows the configuration of box-type JERS-1 together with a SAR antenna and a solar paddle.

There were a lot of problems to be solved in adopting world wide new sensors. I would like to explain some of them for information useful for future satellite development, and to mention some development policy of remote sensing field.

1. Synthetic Aperture Radar (SAR)

Synthetic Aperture Radar installed in ERS-1 launched in July, this year and JERS-1 scheduled to be launched early next year are the first spaceborne SAR since SEASAT thirteen years ago except for SIR (Shuttle Imaging Radar), and they are absorbing worldwide attention. Table 1 provides a summary of the charac-

teristics of SAR installed in SEASAT, SIR-A, SIR-B, ERS-1, JERS-1 and RADARSAT.

The research and development of SAR started 1981 in Japan, but there were no virtual data on SAR in Japan at that time. We started understanding that it would take a very long time to conduct data processing even on a large-sized computer while studying the analytic results of SAR installed in SEASAT and airplanes in papers.

Optical processing was partly utilized at that time and hybrid processing combined with digital processing was also considered, but optical processing is now no longer popular since higher speed processing by computer can be conducted.

In 1982, NEC, MELCO and RESTEC successively succeeded to correlate digitally the raw SEASAT data obtained from NASA. The concept design of spaceborne SAR was started at the same time by NASDA.

As shown in Fig.2, JERS-1 SAR, deployed a 12m x 1.2m antenna in space, can obtain a ground resolution of 6m (18m at 3 looks) at an orbital altitude of 568km, and has a swathwidth of 75 km and an incidence angle of 38.6°.

a) Wavelength and Polarization

Frequency bands used for SAR are X, C, L, and P-band has recently absorbed attention as well. It is known that longer wavelength will allow significant penetration of most vegetation and thin dry soil, but lower ability in identifying small-shaped matters according to data provided from SEASAT and airborne SAR. Since shorter wavelengths can obtain equal resolution with shorter synthetic aperture length, they are suitable for dynamic object observation such as ocean wave observation. C-band is used for ERS-1 in Europe, but L-band was selected as the suitable wavelength for JERS-1 in consideration of the following reasons. Suitable solid-state power amplifier could not be obtained for shorter wavelengths except L-band by technical view point at that time. As for shorter wavelengths, Klystrons and TWT can not be used, because of the weight restrictions. Also the flatness of shorter wavelength antenna will originate in another construction difficulties. In future, if it is possible to use multi-wavelength and multi-polarization in consideration of weight and electric power, the amount of information is expected to

increase remarkably. (Research study report on SAR development, 1981, NASDA)

There are polarization of HH, VV, HV and VH. Since the sensitivities of cross polarization is about 10dB lower, like polarization was first selected. There is almost no difference between HH and VV in sensitivities for land areas, but HH was then selected since it was slightly greater degree of penetration than VV according to data. A lot of information is expected to be obtained from two wavelengths SAR, if observation of ERS-1 and JERS-1 is expected to be operated at the same period.

Fig.3 shows a famous example which observed the situation of ancient rivers several meters below the dry surface of the Sahara Desert by L-band, and the situation of the surface in the vicinity by an optical sensor (LANDSAT TM).

b) Resolution, S/N and Incidence Angle

Azimuth resolution (in the flight direction of the satellite) is one half of the length of its antenna regardless of its distance. How far an antenna can be minimized and resolution can be improved is determined depending on its transmitter peak power and slant range distance. Since the maximum output for JERS-1 was determined to be 1.2kW, an incidence angle of 45° or more requested by users forced to be decreased to a present off-nadir angle of 35° (an incidence angle of 38.6°) by reducing slant range and to increase power density though topographical image distortion could not avoid being slightly bigger.

Fig.4 shows the relationship between noise equivalent reflectivity σ° and incidence angles. The vertically striped area shows the average of natural backscatter σ°. You probably understand why the incidence angle should be determined to be the present value. Since we did not have our own observation values such as various targets of σ° in nature, we had to use data which had been used for NASA's SIR-A, B, C project. Such basic data should be accumulated in advance through repetitive tests by our own airborne SAR.

c) Experiment by Airborne SAR

It was quite difficult to make SAR experiment in advance of the launching of the satellite with SAR since there were no aircraft used for remote sensing experiment in Japan. However,

it was very significant that two experiments could be made for JERS-1 by foreign airborne SAR. But it was regrettable that the results of the experiments could not be used for the design of SAR since the experiments were made after the design was completed. It should have been more significant if the specifications of SAR were determined according to the various results of the experiments.

As for the first experiment, SAR observations were made in 1983 by NASDA at seven test sites (Tsukuba, the foot of Mt. Fuji, the seacoast of Hiratsuka, Oshima Island, Miyake Island, Futatsui (Akita), Kosaka in Hachimantai) in Japan with Sendai Airport as the base by borrowing SAR-580 from CCRS (Canada Centre for Remote Sensing). Miyake Island was added in a hurry as a test site to observe lava flow since its volcano erupted on October 3 one month before the start of the observations.

SAR-580 had three wavelength of X, C, L with the polarization of HH, VV, HV, VH (only one at the same time) and the position was confirmed by displaying quick look images in real time on the aircraft. As for data processing, HDDT was sent to Canada, converted into CCT there, returned to Japan, processed at RESTEC in day and night shift, and finally distributed to people in charge of the project.

The second airborne SAR experiment was made in July, 1990 by JAROS (Japan Resources Observation System Organization) at six test sites (Edward test site, Gabus Valley, Drum Mt., Wind River, Ouachita Mt., Lost River) in the United States by using NASA's DC-8 (Fig. 5). New polarimetric SAR observations could be made which used a combination of three wave lengths C, L, P and polarization of HH, HV, VH, VV. Polarimetric SAR is a new field, which has recently started being researched, aims at increasing its target identification ability in the same way as optical sensors. Multi-parameter SAR, instead of single parameter SAR such as JERS-1, ERS-1, RADARSAT, and so on, is expected to be often used in the future.

Fig.6 shows an example whose observation results are indicated in color by allotting red, green and blue to P, L and C bands respectively.

As for Edward test site, the area was observed by placing a lot of corner reflectors (15 ones) and transponders for calibration at a flat place on the dry bottom of the lake with a very

low background signal level. Since there are not such flat places in Japan, it is difficult to select calibration sites and a complicated measure is considered to be taken by placing delay transponders and shift transponders. Microwave Attenuation by dry soil and forest were observed by L-band, but a lot of data should be accumulated on various conditions. In this regard, aircraft used for remote sensing should be prepared, then new sensors under development, such as SAR, should be tested, and basic data should be accumulated. Even in China experimental observations of X-band airborne SAR are made together with practical use.

2. Optical Sensor (OPS)

The optical sensor installed in JERS-1 has several new attempts. The sensor can make stereoscopic observations in nadir and forward looking in the flight direction of the satellite. A charge coupled device (CCD) is used for the detectors of both short wave infrared (SWIR) bands and visible near-infrared (VNIR) bands. Its mineral resources exploration ability is expected to be improved remarkably by SWIR and stereoscopic images.

Fig.7 shows the schematic diagram of OPS which can obtain at a swath width of 75km through SWIR bands, and by VNIR bands 1, 2 and 3 while stereoscopic observation at forward looking angle of 15.3° through band 4. Table 2 shows the specifications of optical sensors installed in representative earth observation satellites.

a) Characteristics of Short Wave Infrared (SWIR) Bands

As shown in Table 2, the sensor having a short wave infrared (SWIR) band is installed in Landsat TM, but it can not distinguish the difference between detailed reflection characteristics since its band width is wide. The SWIR band of JERS-1 has a wavelength of 1 to 3 μm regarded as one of the most important characteristics. Since TM has the single seventh band while JERS-1 has three separate bands as shown in Fig. 8, it is understandable that JERS-1 aims at superior spectral resolution.

Since the first generation LANDSAT was limited to visible and near infrared bands, the sensor could, frankly speaking, afford to explore only iron oxide. As for the second generation with newly-added SWIR bands, it was the most advantageous to

obtain some information on clay minerals and carbonate stone. If thermal infrared bands is added to this, it may be possible to identify silicate minerals. In the first genaration LANDSAT, the sensor had no SWIR bands at all. In the first half of the second generation, it became possible to recognize the existence of the above-mentioned minerals at most, but the sensor was no better than unsatisfactory results as ever.

JERS-1 has reached the stage of identifying the kinds of minerals within a short period of time, and it is therefore understandable why the satellite is regarded as epochal and attracting global attention. Fig.9 shows the expected results of SWIR bands, and the optimum formation of bands has been designed according to the characteristics of main clay minerals and limestone. JERS-1 is the unique satellite, which has SWIR bands with such high spectral resolution, compared with earth observation satellites launched in the past and scheduled to be launched in the near future.

The main object of remote sensing was essentially to identify lithology by using spectral characteristics, but up to this time, the collection of information on geological structure symbolized by lineaments, was still given overwhelming weight. The collection of information on geological structure does not seem to decrease in importance at all even from now on. However, lithology identification technology, which has been unsatisfactory, is remarkably progressing while such spectral resolution as JERS-1's OPS is improving.

b) Stereo Image

It is advantage of OPS of JERS-1 that stereo images can be obtained by nadir looking through VNIR bands 1 to 3 while forward looking at an angle of 15.3° through band 4 where bands 3 and 4 use the same wavelength from 0.76 to 0.86 μm. Since SPOT makes stereoscopic observations between two orbits, its observation days are different. On the contrary, OPS has the advantage of observation on the same conditions since it observes same area in forward and in nadir at the almost same time from the satellite in the same orbit. Stereo image is required to obtain morphology and digital elevation model (DEM).

c) Detector

Pt-Si Schottky barrier CCD with 4096 elements has achieved excellent results in the development of SWIR detectors, and it is cooled at 77 to 82K by a stirring cycle cryocooler.

d) Cooler

Two systems such as the radiation cooler and the stirring cycle cryocooler were considered to cool SWIR detectors. The structure of radiation cooler was simpler, but stirring cycle cryocooler was developed in consideration of their cooling ability and compatibility with the components of the satellite system such as the SAR antenna, the solar paddle, and so on. The main performance of the cooler is shown in Table 3.

e) Experiments by Airborne OPS

Two OPS experiments by aircraft were made from 1986 to 1988 and from 1989 to 1990 in the United States and Australia by using U. S. GER (Geophysical and Environmental Research Inc.)'s AIS (Aircraft Imaging Spectro-radiometer). Since AIS had finer spectral bands than OPS, simulation images similar to OPS's could be made and analyzed. It was also regrettable that the results of the analysis could not be used for the design of OPS in the same way as SAR.

According to the result of simulation image analysis, band ratios such as 5/6, 7/6, 7/8, 5/7, 5/8 was confirmed to be effective in identifying the mineral species. The distribution of minerals, which could not be grasped by LANDSAT TM, could be identified. In areas with oil fields and natural gas fields, the existence of clay minerals could be presumed and carbonate rocks, could be clearly identified. Oil fields and natural gas fields are distributed in gently-sloping anticline structure. According to simulation image analysis, geological structure could be clearly recognized even in areas with gently-sloping strata.

f) Circumstances of Determining Performance such as Resolution

Trade-offs among spatial resolution, the number of bands and the data transmission bandwidth were considered in determining the performance of OPS system. The data transmission bandwidth was determined to be a maximum transmission ratio of 30Mbps x

2. It was impossible to obtain more than this value owing to restrictions on the data recorder and the allotment of radio regulation. Therefore, data compression was considered, but it was found impossible to achieve this matter either. CCD was developed by aiming at a spatial resolution of 20m or smaller, and then the spatial resolution was determined to be 18.3m by achieving a swathwidth of 75km through CCD with 4096 elements. Based on the determined value, the detector (Pt-Si Schottky barrier CCD with 4096 elements), the cooler (stirring cycle cryocooler) and the high resolution optical system (aspherical catadioptric wide-angle optical system) and other components of OPS have been designed and developed.

The specified value of MTF was 0.1 (Nyquist Frequency) and slightly smaller than that of LANDSAT TM (0.44 at resolution of 30m, 0.76 at 45m). Although OPS of JERS-1 had a high spatial resolution of 18m, MTF standing at 0.1 was in danger of becoming inferior to TM. Therefore, it became necessary to improve MTF to lower its resolution. Where resolution in cross-track direction (Instantaneous Field of View (IFOV) 18.3m = 75km / 4096) was changed, it meant to overrule the premised target of OPS development and to have severe impact on its development schedule. Therefore, it was difficult to change the value of cross-track resolution. However, as for resolution in the along-track direction, since the impact on hardware was rather smaller, the change of the resolution was possible and then the along-track resolution was decided to be changed from 18m to 24m to satisfy the specifications.

Therefore, its resolution was determined to be 18m x 24m. As for the method of redetermining along-track resolution, there had some fear for the anisotropy of pixel. However, the system was concretely examined in the above-mentioned method from the viewpoint of keeping the development schedule, obtaining the specified S/N and MTF by using CCD with 4096 elements, and transmitting multi-bands.

Since SWIR bands of OPS has a bandwidth of 130nm compared with TM with a bandwidth of 270nm, this can be considerably good as the total sensitiveness. Therefore, the more excellent system could have been achieved if the system was comprehensively examined by determining the detector's resolution to be 24m x 24m for example.

3. Conclusion

Remote sensing is increasingly becoming important at present while global environment issues are absorbing public attention. Remote sensing is a new academic field stretching over a lot of special fields. Measures for developing various kinds of earth observation satellites and their sensors by Japan in the future are as follows:

a) An organization for conducting basic research and development of remote sensing should be established. Present weakness of Japan in this field has should be overcome by accumulating basic data there for example.

b) Aircraft used for remote sensing experiments and observation (NASA/JPL's DC8 for example) should be prepared to develop sensors, to obtain and accumulate data by new sensors and to make practical observations (especially in emergency). There were some items which could have been improved if experiments were made in advance of the development of JERS-1.

c) The continuity of earth observation satellites should be regarded as important. There may be some reasons why MOS, JERS-1, TRMM and ADEOS does not have its second one at all. This situation is not desirable to use satellite remote sensing data.

It is impossible to realize the above- mentioned matters very soon. I devoutly hope Japan will strengthen its own system in order to overcome its weakness because Japan is now trying to become more advanced country in the field of satellite remote sensing.

*Table 1, 2 and 3 are inserted in page 12, 16 and 18 respectively.

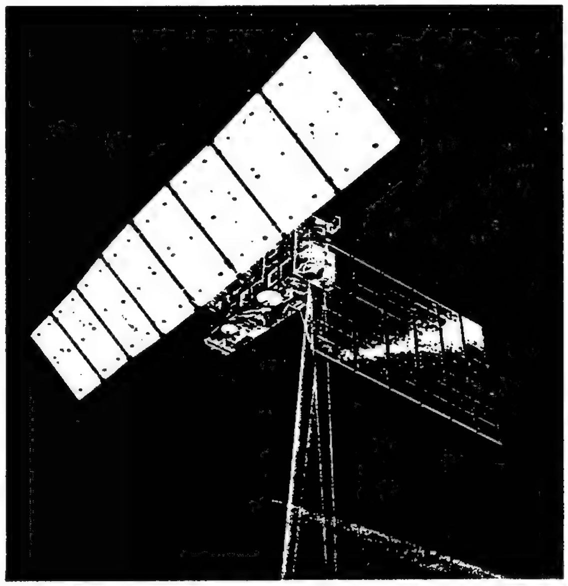


Fig.1 Configuration of JERS-1.

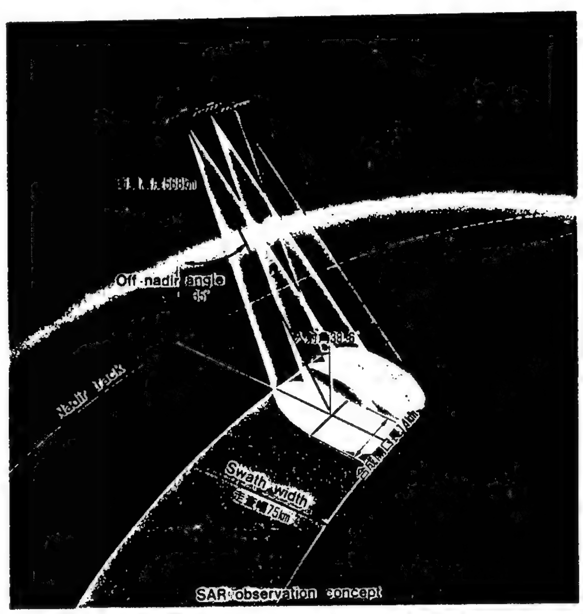


Fig.2 SAR observation concept.

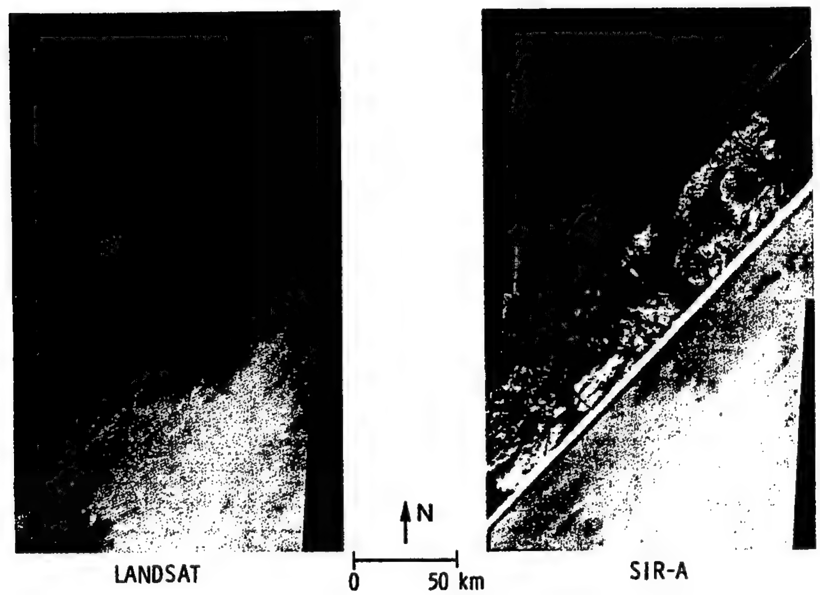


Fig. 3 SAR-A (insert on right) and Landsat images of an area in the Egyptian desert near the Sudan/Egipt border. The radar image clearly shown the morphologic pattern of a drainage network which is barely visible on Landsat.

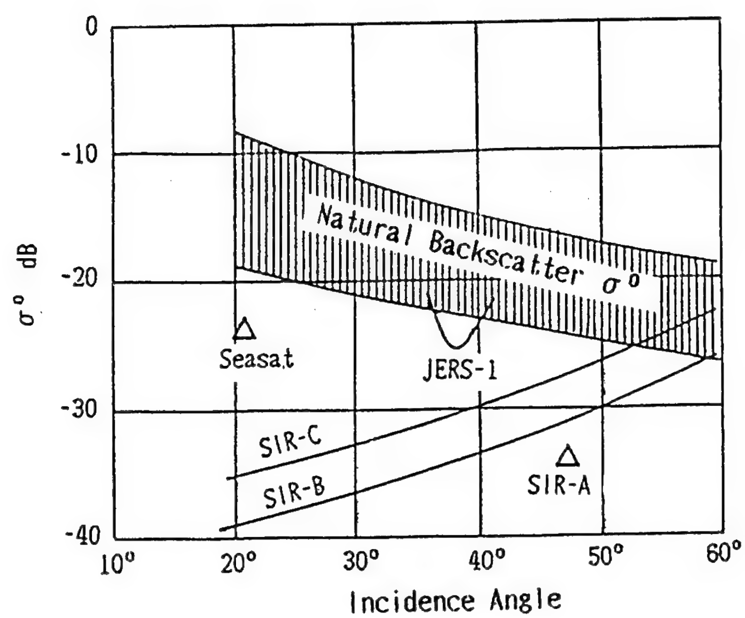


Fig. 4 Noise Equivalent σ^0 of JERS-1.
(Tranmitting peak power 1.1 kW, spacial resolution 18 m, off-nadir angle 35°)
(Values for SEASAT, SIR-C, SIR-B, SIR-A are also shown for reference.)

Fig. 5 DC-8 SAR

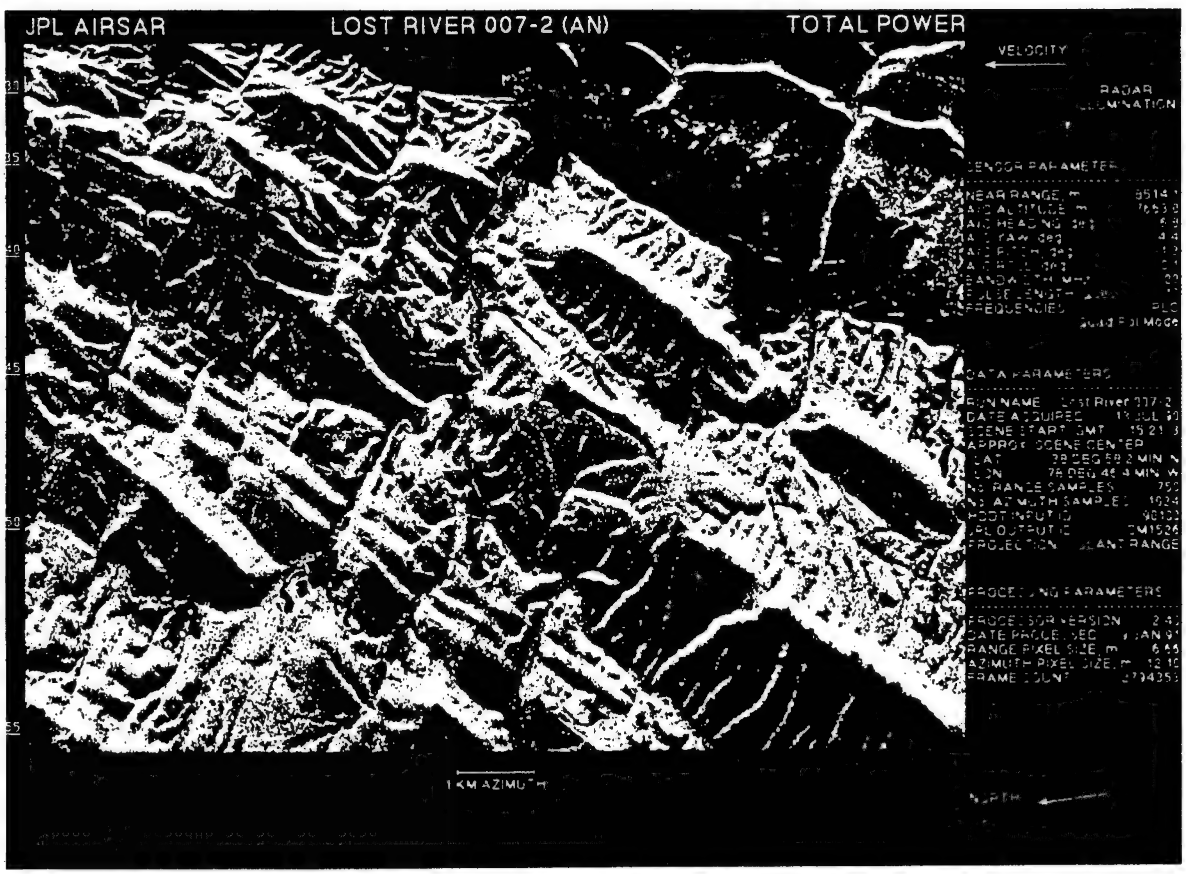


Fig. 6 DC-8 SAR image of Lost River test site.

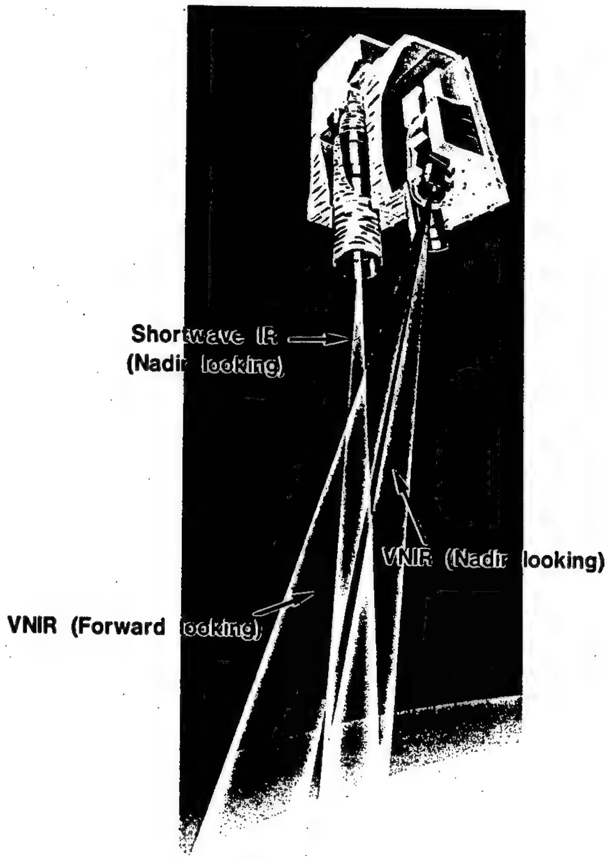


Fig. 7 Schematic diagram of OPS.

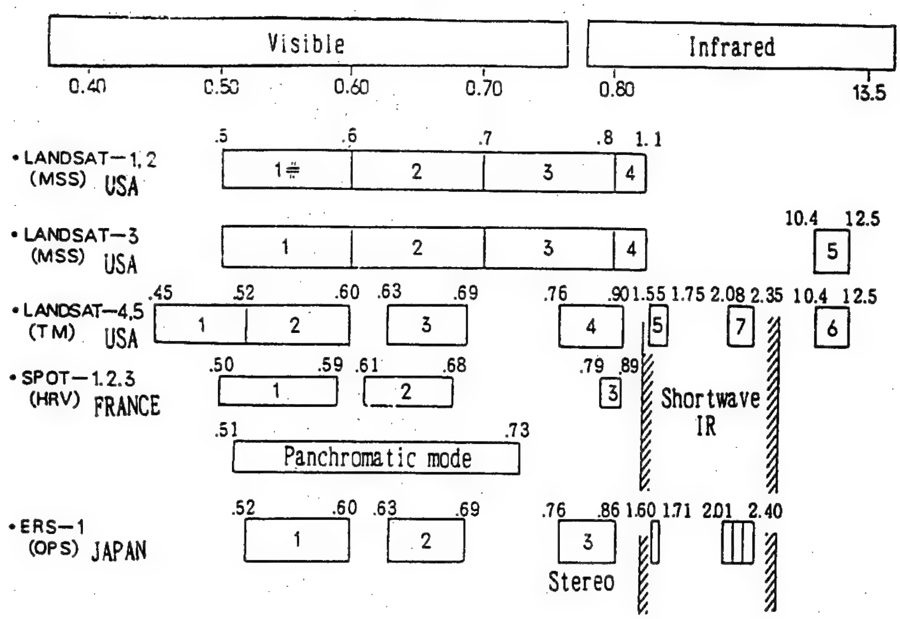
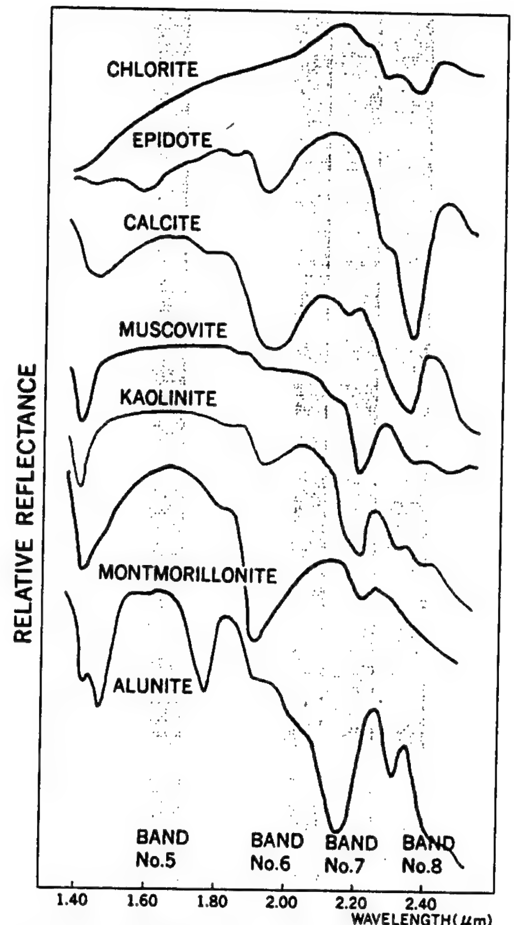


Fig.8 Comparison of the band allocation for optical sensors.



BAND No.	WAVELENGTH(μm)	BAND No.	WAVELENGTH(μm)
1	0.52~0.60	5	1.60~1.71
2	0.63~0.69	6	2.01~2.12
3	0.76~0.86	7	2.13~2.25
4	0.76~0.86(STEREO)	8	2.27~2.40

Fig. 9 Reflection characteristics of shortwave IR.

Research Trends on Remote Sensing at Research Facilities in Japan - The Priority Area Programme on "Better Understanding of Earth Environment via Satellite" funded by the Ministry of Education -

Mikio Takagi (Institute of Industrial Science, University of Tokyo)

The Priority Area Programme on "Better Understanding of Earth Environment via Satellite" funded by the Ministry of Education is going on since 1989 as a three year programme. This programme is the extension of the Special Research on "Higher Order Utilization of Remote Sensing Data from Space", which organized researchers in the fields of microwave, data processing, oceanography, meteorology and land, and covered researches from basic ones to applications. As the result, a group with good cooperation was organized, much communication within the group was made, and each research was promoted strongly. Through this project the importance of earth observation by satellite was recognized and it was decided to propose a priority area programme to promote academic research corresponding to the trends that satellite observation would become very active internationally towards 90's. The research plan was discussed and refined from 1986 to 87 supported by the General Research "Elucidation of Earth Environmental Phenomena Using Multi-temporal and Multi-dimensional Information Observed by Satellite", and submitted to the Ministry of Education and finally this programme was approved.

The objectives of this programme are to establish observation techniques of various kinds of earth environments and to promote basic researches to understand the mechanism of the variations of earth environment based on earth observation information from space. Since the phenomena on the earth cover the wide area in atmsphere, hydrosphere and geosphere, measurement of phenomena is, first of all, essential to the understanding of phenomena. Conventional measurement methods have the disadvantages that, if the region of interest becomes wider, measurement points become corser due to cost and labour, mesurement time differs from points to points, because simultaneous measurement at many points is very difficult, and its frequency is much reduced. In 1960's, as one of the most important results of space development, a new earth observation technique appeared. Namely, that is remote sensing from space, which has the advantages that information covering a wide area can be acquired in a short time and the same area can be observed repeatedly. Therefore, remote sensing provides one of the most essential techniques for earth observation and it is expected that its application fields become wider and wider. So far, LANDSAT, GMS, METEOSAT, GOES, NOAA, SEASAT, HCMM, NIMBUS, SPOT, MOS-1 and so on have been available earth observation satellites, and ERS, ERS-J, Space Stations and others are under development towards 90's.

Since various kinds of satellites are going to be launched in 90's, earth observation will change in quality and volume owing to satellite measurement. Global monitoring of

earth environment, better understanding and prediction of global scale phenomena such as oceanic or atmospheric variations, and management of earth resources attract world-wide interest. And it is expected that satellites will play an important role to solve these problems.
Unfortunately, however, in Japan the system for academic research to apply satellite data to basic researches on earth environment such as atmosphere, ocean and land has not been well established. And, there are a lot of problems to be solved. Therefore, this programme has been approved and realized. Such a global view is one of the most important standpoints of this programme and the outcome will contribute to solve social problems.

This programme intends to promote effectively unique and well organized researches with close cooperation between science and engineering in both hardware and software sides. Researchers covering wide fields have not been organized in Japan until the three year's Special Research on "Higher Order Utilization of Remote Sensing Data from Space" had started. In the previous research, close cooperation between scientists in geoscience such as oceanography and meteorology and in engineering such as data processing and remote sensing was set up and researches were promoted up to high academic level. And through this research future research direction became more clearly. Namely, it was recognized that further intensive academic research is strongly required for better understanding of earth environment via global observation and that there has been no system in Japan for academic rearchers to promote understanding of earth environment via satellite. Therefore, this programme intends to establish such a system.

The earth environments surrounding human activities are shown in Fig. 1. The features of this programme lies in the points to promote academic research from a new viewpoint and common basic research to support it. As academic research from a new viewpoint, problems in boundary area, which have not been studied well by ordinary independent science fields such as atmosphere, hydrosphere, and geosphere, will be the target of this research programme. For example, boundary area between atmosphere and hydrosphere: remote sensing of air-sea interaction system, boundary area between atmosphere and geosphere: remote sensing of evaporation and exhalation - snow and rainfall interaction system, and boundary area between hydrosphere and geosphere: remote sensing of water ciculation and soil moisture are selected.
As common basic technologies essential to the researches on boundary areas between atmosphere and hydrosphere, atmosphere and geosphere, and hydrosphere and geosphere, researches on measurement and information processing are promoted. As for measurement, microwave remote sensing has been selected, because it is expected to play an important role in the future earth observation for atmosphere, hydrosphere, and geosphere, but so far its basic research has not been studied well in Japan. And as another common basic techology, advanced information processing for higher order utilization of satellite data from the global point of view to promote researches on atmo

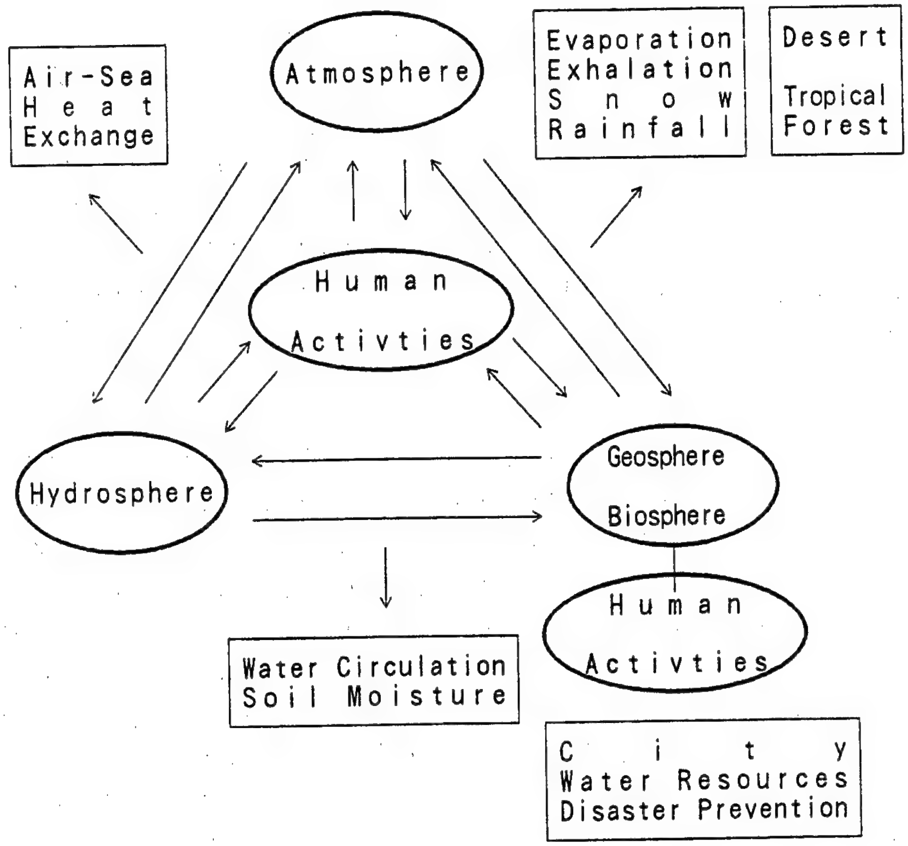


Fig. 1 The Earth Environments Surrounding Human Activities.

sphere, hydrosphere, and geosphere is investigated. Five research fields have been selected as shown in Fig. 2.

Through discussion on how to promote effectively unique and well organized research programme with close cooperation between science and engineering in both hardware and software sides, the following five planned researches have been selected.

A Basic Study on Earth Observations by Microwaves
Leader: Haruto HIROSAWA (Institute of Space and Astronautical Science)

B Global Change Analysis of Biosphere Using Satellite Data - Interaction between Atmospheric and Terrestrial Aspects -
Leader: Shunji MURAI (Institute of Industrial Science, University of Tokyo)

C Study on Physical Process of Water Cycle over the Land
Leader: Junsei KONDO (Geophysical Institute, Tohoku University)

D Study of Air - Sea Interaction Using Satellite Data
Leader: Yasuhiro SUGIMORI (School of Marine Science and Technology, Tokai Universiy)

E Higher Order Processing of Earth Observation Information
Leader: Ryuzo YOKOYAMA (Faculty of Engineering, Iwate University)

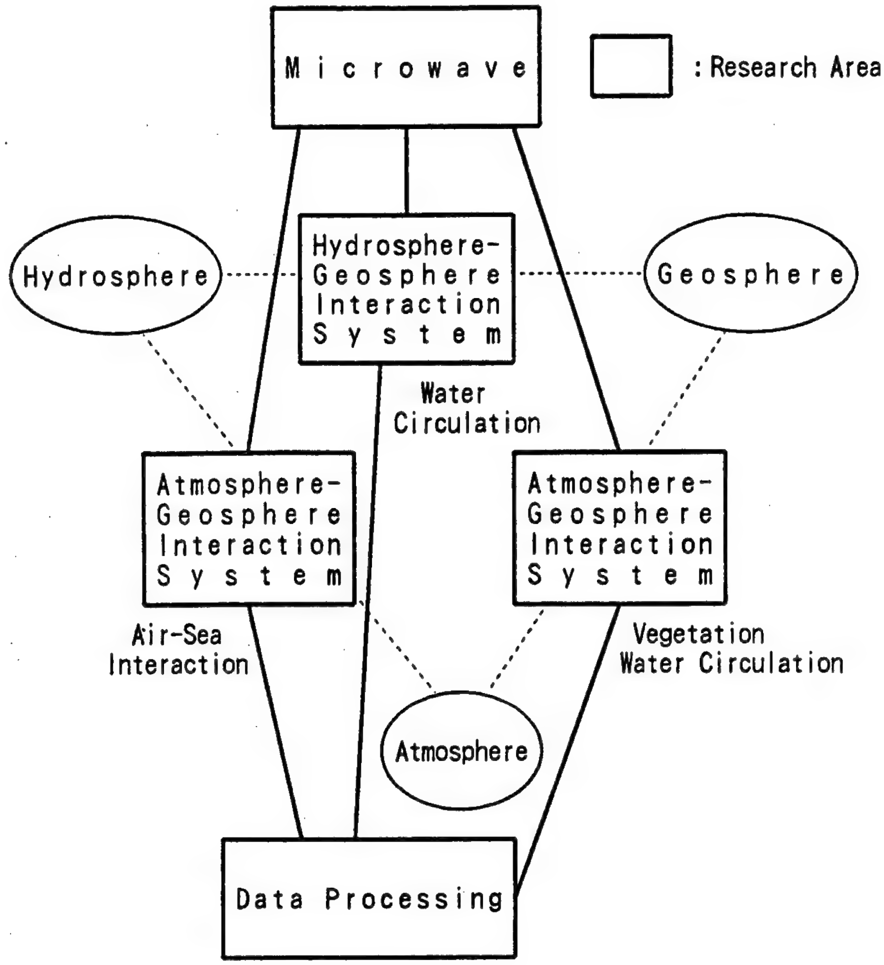


Fig. 2 Research Areas of This Project

The objectives of each planned research are as follows:

A Basic Study on Earth Observations by Microwaves

1. A study on radar polarimetry.
2. A study on microwave measurement of air - sea boundary processes.
3. Backscattering from windwaves with application to microwave backscatter.
4. Investigation of sea - ice parameter derived from microwave remote sensing.

B Global Change Analysis of Biospace using Satellite Data - Interaction between Atmo - spheric and Terrestrial Aspects -

1. The Biosphere's evaluation system using global vegetation index of NOAA and the geo - graphic information will be made in order to compare the difference between re - gions of the continents. The final result is to provide the evaluation map of global bio - envi - ronment by using inmage processing technique.
2. The global change analysis will be calibrated using local data based on climatologi - cal and ecological zone aspect.
3. The vegetatioon map and vegetation change in South East Asia region will be made

and compared.

C Study on physical processes of water cycle over the land

1. Water and heat balance at the ground surfaces (e.g.vegetated surface, bare soil and snow cover).
2. Soil moisture measurement by active micro wave remote sensing techniques.
3. Development of a rainfall prediction method by use of a three-dimensionally scanning radar.
4. Study on snowfall and snow cover using remote sensing.
5. Large scale water cycles as climate systems in relation to maintenance processes of precipitation over the continent in East Asia.

D Study of Air-Sea Interaction Using Satellite Data

1. Techniques to estimate air-sea fluxes by satellite data will be developed using the satellite data and in-situ data. The spatial distribution of heat flux in wide area will be determined. Satellite observation of sea surface temperature and atomospheric moisuture will be studied.
2. Observations in Tanabe Bay will be continued for understanding the relation between oceanographic mixed sturacture of the skin-layer near sea surface and heat-flux through the sea surface. The short term variations of ocean mixed layer will be analyzed using satellite data.
3. Air-mass modification process in an cold air outbreak over the Eastern China Sea is investigated by analyses of cloud patterns by GMS and a heat budget calculation based on observational data obtained by a meteorogical bouy operated by JMA. A simulation program of radiative transfer calculation for an atmosphere-ocean model including cirrus cloud and broken cloud will be developed. Solar radiation at the sureface will be measured using pyranometers and a sunphotometer.
4. An algorithm to estimate the vertical distribution of phytoplankton pigments using underwater irradiance spectra will be developed. The relation between the pigments distribution and satellite data will be also investigated.

E Higher Order Processing of Earth Observation

1. The development of integrated image interpretation system based on artificial intelligence methods.: The fundamental design of the expert system to handle the land use and the land cover classification has been almost finished last year. In this year, the research activities will be directed to develop efficient classification algorithms based on the knowledge baseand by using spatial informations of pixels. The validation tests of their efficiencies will be proceeded.
2. Development of modelling techniques for spatial and temporal phenomena of environment based on the remotely sensed data.: In general, environmental phenomena are spatially and temporally changing. The two dimensional data of images and the frequent observations are the major advantages of remote sensing. Under the tittle, a

new modelling technique to describe the spatial andtemporal behaviors of environmental phenomena is going to be developed by making use of remotely sensed data. As a practical example for the model development will be taken to be a runoff model of rain and snow-melt waters.

3. Development of efficient data base system.: Efficient algorithms for data compression of remotely sensed image data are to be developed under the subject. But, for the time being, the main forces are directed to the NOAA AVHRR data compression algorithms in the detections of the sea surface temperature and the vegetation index. The AVHRR images data have been received in Institute of Industrial Science, University of Tokyo, and widely used by many researchers of this project. In the final stage, a data base system of the archived AVHRR image data is expected to be installed in the Institute.

Each planned research is the core of a group composed of the related research topics, which were selected from generally submitted proposals for 1990. Each year the selection of proposal is made. The table I shows the organization and list of research themes for 1990. Through this programme, the following developments are expected:

(1) Understanding of the mechanism of various phenomena with complicated mutual interaction in boundary areas using satellite data. (Air-sea interaction, Evaporation, exhalation and rainfall in water circulation, Soil moisture and in- and out-flow interaction and etc.)

(2) Trace of wide and long term global change (Deforestation and soil run out, Variation of ocean current, Desertation, Trace of NVI)

(3) Evaluation and prediction of earth environment (GIS, Evaluation of productivity of land)

(4) Establishment of basis of microwave remote sensing technology

(5) Development of advanced information processing technology for earth environment information

Working Groups have been established to promote researches on the common problems in a group or inter-group problems as shown below.

Working Groups

Group B: Grobal Change Analysis of Biosphere Using Satellite Data -Interaction between Atmospheric and Terrestrial Aspects-

Geographic Database

Chair: Ryutaro TATEISHI (Remote Sensing and Image Research Center, Chiba University)

Eco-climate Map

Chair: Kazuo FUJIWARA (Environmental Science Center, Yokohama National University)

Ozone

Chair: Hiroshi FUKUNISHI (Upper Atmosphere and Space Research Laboratory, Tohoku University)

Group C: Study on Physical Process of Water Cycle over the Land

Water Circulation in Terrestial Region

Chair: Junsei KONDO (Geophysical Institute, Tohoku University)

Group D: Study of Air - Sea Interaction Using Satellite Data

Ocean Color

Chair: Yasuhiro SUGIMORI (School of Marine Science and Technology, Tokai Universiy)

Workstation

Chair: Hajime FUKUSHIMA (School of High - Technology for Human Welfare, Tokai Universiy)

Group E: Higher Order Processing of Earth Observation Information

NOAA Satellite Data Analysis

Chair: Ryuzo YOKOYAMA (Faculty of Engineering, Iwate University)

Development of Image Processing Algorithm

Chair: Teruhisa SHIMODA (Professor, Tokai Research and Information Center, Tokai University)

Development of NOAA AVHRR Data Processing Program Package

Chair: Teruhisa SHIMODA (Professor, Tokai Research and Information Center, Tokai University)

Working groups have meetings, which is open widely for every one interedted in this field. So, the announcemnt is mailed to not only all members of the programme but also the people in the outside of this programme those who have interest in. The newsletter of this programme is issued three times a year for the better communication.

Also, the General Supervising Commuttee was organized. Eight authorities related to this programme were invited from the outside of the program to ask their evaluation and comments. And the members from the inside of the programme and group leaders joined the committee to decide the policy of the programme, to adjust the direction of research between groups and teams, to promote new project researches and to plan symposia. The committee tries to allot data center - like parts to engineering research institutes and to manage them efficiently, sharing resources of voluntary centers for data processing and distribution. For this purpose, database sytem on earth environment information, database sharing, and resources utilization between researchers via Science Information Network will be promoted strongly.

"Better Understanding of Earth Environment via Satellite" Research Organization and Research Plan

Supervising Committee

Head Investigator

Mikio TAKAGI (Professor, Institute of Industrial Science, University of Tokyo)
Programme Leader

Investigators

Tomio ASAI (Director, Ocean Research Institute, University of Tokyo)

Haruto HIROSAWA (Professor, Institute of Space and Astronautical Science)
Group Leader: Basic Study on Earth Observations by Microwaves

Hiroshi INOSE (Director, National Center for Science Information System)

Sadao KAWAGUCHI (Professor, National Institute of Polar Research)

Junsei KONDO (Professor, Geophysical Institute, Tohoku University)
Group Leader: Study on Physical Process of Water Cycle over the Land

Hideaki KUNISHI (Professor Emeritus, Kyoto University)

Akira MIYAWAKI (Director, Environmental Science Center, Yokohama National University)

Shunji MURAI (Professor, Institute of Industrial Science, University of Tokyo)
Group Leader: Global Change Analysis of Biosphere Using Satellite Data

Makoto NAGAO (Professor, Faculty of Engineering, Kyoto University)

Jun NISHIMURA (Director, Institute of Space and Astronautical Science)

Hiromi SHIIGAI (Professor, Tsukuba University)

Yasuhiro SUGIMORI (Professor, School of Marine Science and Technology, Tokai Universiy) Group Lader: Study of Air - Sea Interaction Using Satellite Data

Takao TAKEDA (Directer, Water Research Institute, Nagoya University)

Yoshiaki TOBA (Professor, Faculty of Science, Tohoku University)

Ryuzaburo YAMAMOTO (Professor, Faculty of Science, Kyoto University)

Ryuzo YOKOYAMA (Professor, Faculty of Engineering, Iwate University)
Group Leader: Advanced data processing and data base techniques for earth obser - vation

Group A: Basic Study on Earth Observations by Microwaves

Head Investigator

Haruto HIROSAWA (Professor, Institute of Space and Astronautical Science)

Research on Radar Polarimetry

Investigators

Yoshinao AOKI (Professor, Faculty of Engineering, Hokkaido University)

Microwave Measurement System for Snow and Ice Observation Satellites and Acquisition of Basic Data

Naoto EBUCHI (Research Associate, Faculty of Science, Tohoku University)

A Fundamental Study on Microwave Measurement of Air-Sea Boundary Processes

Sadao KAWAGUCHI (Professor, National Institute of Polar Research)

Derivation of Cloud and Sea Ice Distribution in the Antarctic from Satellite Data

Hisashi MITSUYASU (Professor, Research Institute for Applied Mechanics, Kyushu University)

Research on Improvement of Accuracy of Ocean surface Wind and Waves Measurements from Satellite

Akira NISHITSUJI (Professor, Muroran Institute of Technology)

Microwave Measurement System for Snow and Ice Observation Satellites and Acquisition of Basic Data

Nobuo ONO (Professor, National Institute of Polar Research)

Investigations of Sea-Ice Parameter Derived from Microwave Remote Sensing

Masahiro SUZUKI (Professor, Hokkaido Institute of Technology)

Microwave Measurement System for Snow and Ice Observation Satellites and Acquisition of Basic Data

Takao TAKEDA (Professor, Water Research Institute, Nagoya University)

Estimation of Cloud-water Amount by a Microwave Radiometer

Yoshiaki TOBA (Professor, Fuculty of Science, Tohoku University)

A Fundamental Study on Microwave Measurement of Air-Sea Boundary Processes

A Study on Radar Polarimetry

Haruto HIROSAWA (Professor, Institute of Space and Astronautical Science)

Polarization is an important parameter in radar remote-sensing. Radar polarimetry is extensively studied in the field of radar remote-sensing in theseyears. This study aims to explore fundamental capability of the radar polarimetry. A stress is placed on a microwave-signature studies point of view.

We have being carried out experiments on polarimetric back-scattering measurements from random media, using natural trees and artificial randam targets. In the first and second years, we built C- and X-band multi-polarization scatterometers for laboratory-use, measured polarimetric back-scattering characteristics of coniferous trees, developed three-dimensionalartificial random media composed of needle-like

and disc - shape scatterers and measured back - scatterings from those targets, carried out theoretical modelling on polarimetric back - scatterings, and developed an artificial random target for studying surface scattering processes.

In this year we continue experiments on polarimetric back - scatterings from random media using volume and surface scattering model targets, extend theoretical modelling studies, and summarize results of three years studies. We will get a conclusion which increases our understandings on natures and usefulness of polarization in radar remote - sensing.

A Fundamental Study on Microwave Measurement of Air - Sea Boundary Processes

Yoshiaki TOBA (Professor, Fuculty of Science, Tohoku University)
Naoto EBUCHI (Research Associate, Faculty of Science, Tohoku University)

In this study, microwave backscattering from wind - wave surfaces is investigated. Laboratory experiments have been performed using a wind - wave tank. AX - band (9.6 GHz) microwave scatterometer which can detect Doppler frequency of backscattered signal is used. Attention is paid to the propagatingvelocities of fine structures of wind - wave surfaces which mainly contribute to microwave backscatterings. In order to clarify the relationship between themicrowave backscattering and the fine surface structures, the beam of microwave is focused by using an ellipsoidal antenna, which has a half - power beam width of 13cm on the focal plane. Data analysis relating the mechanisms of microwave backscattering with the processes of air - water turbulent boundary layer will be made.

Research on Improvement of Accuracy of Ocean Surface Wind and Waves Measrements from Satellite

Hisashi MITSUYASU (Professor, Research Institute for Applied Mechanics, Kyushu University)

Microwave backscattering signatures of wind wave surfaces have been measured simultaneously with winds and waves in a large wind - wave tank by using a X - band scatterometor at 9.6GHz with horizontal polarization. Various relations among the backscattered microwave power, incidence angle θ, characteristic wind speeds, u and u 10 and wind wave spectrum have been studiedwithin the ranges $-35° \leq \theta \leq 35°$ and 3.5m/s$\leq$u10$\leq$20.5m/s, where u is the friction velocity of the wind and u10 is the wind speed at the height z=10m. It has been shown that the friction velocity dependence on various quantities such as the wind speed u10, the backscattered microwave power and the high frequency wave spectrum changes near the wind speed u of - 0.2m/s and that these changing patterns are quite similar. The results show a close connection among the high froquency wave spectrum, the wind structure and the backscatteredmicrowave power.

Investigations of Sea - Ice Parameter Derived from Microwave Remote Sensing

Nobuo ONO (Professor, National Institute of Polar Research)

Satellite - borne remote sensing sensors are important in the sea - ice researchand have provided essential observations of sea - ice extent, surface temperature,ice surface morphology and ice movement. Ice thiskness is one of the most difficult parameter to derive from satellite remote sensing data, because the ice thickness data are masked with snow cover and brine on the sea - ice surface. Objectives of this research are: (1) to clarify the effects of the snow cover and of the brine on the sea - ice remote sensing data, and (2) to investigate sea - ice parameter derived from passive microwave sensor using MOS - 1 MSR data in combination with high resolution MESSR data and with visible/infrared VTIR data.

Estimation of Cloud - Water Amount by a Microwave Radiometer

Takao TAKEDA (Professor, Water Research Institute, Nagoya University)

Following research subjects on the estimation of cloud - water amount by a microwave radiometer will be studied:

(1) In Western North - Pacific Cloud - Radiation Experiment (WENPEX) of Japan WCRP, the spatial distributions of cloud - water amount in maritime low - level clouds were observed by an air - borne microwave radiometer, and air - borne cloud droplet spectrometer and other instruments in Southwest islands Area. By using these data, the accuracy of cloud - water amount estimated by a microwave radiometer will be evaluated and the characteristic features of cloud - water amount distribution will be studied.

(2) In WENPEX, when satellite MOS - 1 passed over Southwest Island Area, the simultaneous observation of maritime low - level clouds by MOS - 1 and instrumented aircraft was made. The accuracy of cloud - water amount estimated by the data of a satellite - borne microwave radiometer will be evaluated.

(3) The distribution of cloud - water amount in the area around Japan and its time variation will be summarized on the basis of the analysis results of satellite data in this research projects, and the research subjects which should be studied in future WCRP GEWEX projects and other projects in association with global change will be presented.

Derivation of Cloud and Sea Ice Distribution in the Antarctic from Satellite Data

Sadao KAWAGUCHI (Professor, National Institute of Polar Research)

Collect ground truth data of sea ice and atmosphere in the Antarctic, and set up an algorithm of deriving sea ice distributions and atomospheric effects by the satellite data as MOS - 1 MSR.

(1) Analyze the data of atmospheric parameters such as water vapor amount, liquid wa -

ter content and ice water content from the ground - based observation by microwav - eradiometer, vertical pointing and PPI radar and aerological data.

(2) Analyze the data of sea ice parameters and sea water obtained by the airborne ob - servation (microwave radiation, VTR, AXBT etc.), ground - based observation of sea ice condition, growth and decay and sea water temperature and sea ice buoy.

(3) Estimate sea ice distributions and condition together with atmospheric effects from satellite data such as MOS - 1 MSR and Nimbus - 7 or DMSP SSMI, with the aid of ground truth data obtaind in (1) and (2).

Studies on Microwave Measurement System for Snow and Ice Observation Satellite and Aquisition of Basic Data

Masahiro SUZUKI (Professor, Hokkaido Institute of Technology)
Yoshinao AOKI (Professor, Faculty of Engineering, Hokkaido University)
Akira NISHITSUJI (Professor, Muroran Institute of Technology)

The Following themes will be studied by three investigators.

(1) A technique of high - speed prosessing of snow search rader system holographic imaging radar system) with a linear antenna array.

(2) Analyses of stratigraphic images of snowpack obtained by an FM - CW radar sys - tem.

(3) An active remote sensing techniqe by pulse - modulated radar mounted on an artifi - cial satellite for the measurement of snowlay.

(4) Passive remote sensing of snow - covered area by the microwave scanning radiome - ter mounted on MOS - 1.

(5) Optical processing of image data obtained by synthetic aperture radars.

Group B: Global Change Analysis of Biosphere Using Satellite Data
- Interaction between Atmospheric and Terrestrial Aspects -

Head Investigator

Shunji MURAI (Professor, Institute of Industrial Science, University of Tokyo)

Analysis of Variation of Vegetation Index

Investigators

Yukio KUBO(Associate Professor, Faculty of Environmental Information, Keio University)

Map and Geographic Information System

Toshibumi SAKATA(Professor, Tokai Research and Information Center, Tokai University)

Image Analysis and Image Output

Kuniyoshi TAKEUCHI(Professor, Faculty of Engineering, Yamanashi University)

Hydrological Analysis

Kazue FUJIWARA(Professor, Institute of Environmental Science and Technology, Yokohama National University)

Botanical Ecology

Eiji YAMAJI (Associate Professor, Faculty of Agriculture, University of Tokyo)

Evaluation of Global Biological Ecology

Ryutaro TATEISHI(Associate Professor, Remote Sensing and Image Research Center, Chiba University)

Land cover monitoring by global GIS

Takehiko MIKAMI (Professor, Faculty of Science, Tokyo Metropolitan University)

Estimation of thermal environment by overlapping the satellite image on DTM and its relation ship with the distribution of forest zone

Ikuo HORIGUCHI(Professor, Faculty of Agriculture, Hokkaido University)

Studies on the estimations for changing of heat & water transfer due to the deforestation using satellite data

Kazutaka IWASAKI (Associate Professor, Hokkaido University)

Analysis of the Atmospheric Environments over Asia and Oceania Based on the Satellite and Surface Data

Jun MATSUMOTO (Research Associate, Department of Geography, University of Tokyo)

Climayic Environments in East Asia

Isamu HIROTA (Professor, Faculty of Science, Kyoto University)

A Study on the Long-term Variations of the Stratospheric Ozone based on the SBUV Satellite Measurement

Hiroshi FUKUNISHI (Professor, Upper Atmosphere and Space Research Laboratory, Tohoku University)

Study on the Variation of Stratospheric Ozone using the TOVS Data of NOAA Satellites

Akiyoshi MATSUZAKI (Research Associate, Institute of Space and Astronautical Sci ence)

Global Study on Change of Atmospheric Environment by Analysis of LAS - Data (EXOS - C)

Nobuo TAKEUCHI (Head, National Institute for Environmental Studies)

Profile Derivation of the Global Trace Gas Distribution from Satellite Dat

Global Change Analysis of Biosphere Using Satellite Data

- Interaction between Atmospheric and Terrestrial Aspects -

Shunji MURAI (Professor, Institute of Industrial Science, University of Tokyo)

Yukio KUBO (Associate Professor,

Faculty of Environmental Information, Keio University)

Toshibumi SAKATA (Professor,

Tokai Research and Information Center, Tokai University)

Kuniyoshi TAKEUCHI (Professor, Faculty of Engineering, Yamanashi University)

Kazue FUJIWARA (Professor,

Institute of Environmental Science and Technology, Yokohama National University)

Eiji YAMAJI (Associate Professor, Faculty of Agriculture, University of Tokyo)

Missions

(1) The global vegetation map (Eco - Cliamte Map) without the human activity will be made in order to compare the difference with the global vegetation map with the hu - man activity. The final result is to provide the evaluation of global bio - environment under the influence of the human activity.

(2) The global change analysis will be calibrated using local data based on climatologi - cal using ecological zone aspect.

(3) The global image data book will be provided.

Land Cover Monitoring by Global GIS

Ryutaro TATEISHI (Associate Professor,

Remote Sensing and Image Research Center, Chiba University)

Research Plan:

(1) AVHRR Ch.1 and Ch.2 data in NOAA CVI products will be corrected in term of so - lar zenith angle. Global NDVI data will be newly produced from the corrected AVHRR Ch.1 and Ch.2 data.

(2) Land cover change will be detected globally by using newly produced NDVI data.

(3) Land cover will be categorized globally by the integrated use of newly produced NDVI data, temperature data and rainfall data.

Estimation of Thermal Environment by Overlapping the Satellite Image on DTM and its Relationship with the Distribution of Forest Zones

Takehiko MIKAMI (Professor, Faculty of Science, Tokyo Metropolitan University)
Michio NOGAMI (Professor, Faculty of Science, Tokyo Metropolitan University)
Akihiko KONDO (Research Associate, Faculty of Science, Tokyo Metropolitan University)

Research Plans:

We had analyzed zonation of natural forest in Japan under control of Warmth Index. In the present year, we are planning to treat the other controlling factors such as land-form, geology, soil, snow pack depth, potential evapotranspiration, lowest air tempera-turem plant growth period, thermal inertia etc. The average (or climatological) thermal inertia map will be calculated from daily thermal inertia maps for typical days of differ-ent seasons and different meteorological conditions.

Studies on the Estimations for Changing of Heat & Water Transfer due to the Deforestation Using Satellite Data

Ikuo HORIGUCHI (Professor, Faculty of Agriculture, Hokkaido University)
Masatosi AOKI (Associate Professor, Faculty of Agriculture, Hokkaido University)
Hiroshi TANI (Research Associate, Faculty of Agriculture, Hokkaido University)
Takashi MACHIMURA (Research Associate, Fculty of Agriculture, Hokkaido University)

Research Plan:

The following three subjects will be performed in this study.

(1) The collection of meteorological data and land use data in tropical rainfall areas of south east Asis

Some meteorological data and land use data in south east Asia will be collected for the estimations of 1.5m-height air temperature and evapotranspiration using satellite data.

(2) The basic studies for the estimation of 1.5m-height air temperature and evapotran-spiration

The estimations of 1.5m-height air tempeature and evapotranspiration will be exam-ined by compared satellite data with data measured at the forest.

(3) The estimations of 1.5m-height air temperature and evapotranspiration in tropical rainfall areas using satellite data

1.5m-height air temperature and evapotranspiration on forest and deforestation in tropical rainfall areas will be estimated using GMS IR data.

Climayic Environments in East Asia

Jun MATSUMOTO (Research Associate,
Department of Geography, University of Tokyo)

Research Plans:

The purpose of this research is to show the seasonal change processes and their regional differences based on 5-day data measured by meteorological satellites and/or conventional land based observations in East Asian region. Distribution and seasonal evolution of cloud, rainfall, wind and air-mass are mainly analyzed.

A Study on the Long-term Variations of the Stratospheric Ozone based on the SBUV Satellite Measurement

Isamu HIROTA (Professor, Faculty of Science, Kyoto University)
Masao SHIOYA (Research Associate, Faculty of Science, Kyoto University)

Research Plans:

Long-term variations of the stratospheric ozone are investigated by using the ozone mixing ratio data from the solar backscatter ultraviolet (SBUV) instrument and the total column ozone data from the total ozone mapping spectrometer (TOMS) instrument on board the Nimbus 7 satellite. Special attention is paid to the relation between the dynamical and photochemical aspects of the stratospheric long-term variations such as the quasi-biennial oscillation, the semi-annual oscillation and the long-term trend.

We have already had the following global datasets:

a. the SBUV ozone mixing ratio data (1978-1987)
b. the TOMS total column ozone data (1978-1989)
c. the stratospheric temperature and height data provided by the National Meteorological Center (NMC) (1978-1990)
d. the tropospheric meteorological data provided by the European Center for Medium Range Weather Forecasts (ECMWF) (1980-1990)

By using these datasets the following research plans are proposed.

1. The long-term variations in profile ozone and total ozone at extra-tropical latitudes are investigated on the basis of the equatorial results completed in the last year.
2. Dynamical-photochemical coupling is investigated in relation with the dynamical quantities such as wind and temperature.

Study on the Variation of Stratospheric Ozone using the TOVS Data of NOAA Satellites

Hiroshi FUKUNISHI (Professor,
Upper Atmosphere and Space Research Laboratory, Tohoku University)
Yoshiaki TOBA (Professor, Geophysical Institute, Tohoku University)
Shoichi OKANO (Research Associate,
Upper Atmosphere and Space Research Laboratory, Tohoku University)
Hiroshi KAWAMURA (Associate Professor,

Geophysical Institute, Tohoku University)
Takashi YAMANOUCHI (Associate Professor, National Institute of Polar Research)

Research Plan:

The facility for reception and analysis of the real time data from earth observing satellites is installed at the Faculty of Science, Tohoku University. Using this facility we are receiving the HRPT data of NOAA satellite 4 times a day. Our study will be carried out based on these data inthe following way:

1. The data of channel 9 (ozone 9.6 micronband), channels 1,2,3 (correspond to vertical temperature profile in the ozone layer), and channel 8 (coresponds to surface temperature) of HIRS/2 sensor are extracted from NOAA - HRPT data set.
2. Total ozone amount is determined using regression method from the brightness temperature data for the above channels along with the transmittance of the ozone layer. Determination of regression coefficients is made from comparison between the TOVS data and the TOMS data around Japan for combinations of latitudinal regions and seasons. The transmittance of the ozone layer is obtained from brightness temperatures at channels 8 and 9 along with the effective temperature, Te, of the ozone layer. A method for obtaining Te which gives the optimal derivation of total ozone will be developed. Further, the angle correction for slant looking of the HIRS/2 sensor, so far applied only to the transmittance of the ozone layer and the channnel 9 data, will be carried out for all channnels.
3. Horizontal distribution of total ozone amount will be derived using the regression coefficients along with the HIRS/2 data with a spatial resolution of 17 - 58km. Particulary, derivation of nighttime totalozone will be tried.
4. Horizontal distribution of total ozone obtained from the NOAA - TOVS data will be compared to the ozone map derived from the NIMBUS7 - TOMS data. Variation of total ozone over Japan will be studied in combination with meteorological data from the global analysis model, ozonsonde data, and the altitude profiles of ozone measured with a laser heterodyne spectrometer at Sendai.
5. The results on the variation of ozone over Japan will be compiled and the mechanism for the variation will be studied.

Profile Derivation of the Global Trace Gas Distribution from Satellite Data

Nobuo TAKEUCHI (Head, National Institute for Environmental Studies)
Makoto SUZUKI (Senior Researcher, National Institute for Environmental Studies)
Tatsuya YOKOTA (Senior Researcher, National Institute for Environmental Studies)
Masao MATSUMOTO (Associate Professor, Kyushu Institute of Technology)

Plan of current year study

In the previous year, the NIMBUS - 7 TOMS data, version 5 and 6, which were quantitized by NASA, were analyzed in the West Pacific region near Japan for summer season in 11 years. There some sigantures, typical to typhoons were found and the mechanism

of the features were investigated in comparison with meteorological objective data. Further traditional method for deriving trace gas profile were studied with a laser hetero-dyne solar occultation method. In the current year, this thema will be further developed from the point of view of stratosphere - troposphere exchange process.

The research plan of the current year is as follows:

(1) The relation between the typhoon on TOMS dataand the meteorological conditions will be further studied, and a method of upper tropospheric motion by TOMS data will be investigated.

(2) The stratospheric and tropospheric air exchange mechanism will be investigated, using thesatellite data, and meteorological process will be calculated in terms of potential vorticity.

(3) Features of a solar occultation laser hetero-dyne sensor in the near infrared region will be clarified using a FASCODE-3 atmospheric optical model.

Group C: Study on Physical Process of Water Cycle over the Land

Head Investigator

Junsei KONDO (Professor, Geophysical Institute, Tohoku University)

Heat Budget of Vegetation and Bare Soil

Investigators

Katsumi MUSHIAKE (Professor, Institute of Industrial Science, University of Tokyo)

Room Experiment of Trace of Soil Moisture by Microwave Remote Sensing

Shuichi IKEBUCHI (Professor, Disaster Prevention Research Institute, Kyoto University)

Analysis of Rainfall Mechanism by Satellite and Three-dimensional Radar

Toshio KOIKE (Associate Professor, Nagaoka University of Technology)

Analysis of Snowfall Phenomena by Satellite Remote Sensing

Kuranoshin KATO (Research Associate, Water Research Institute, Nagoya University)

Large-scale water cycles and rainfall over the land in East Asia

Renji NARUSE (Associate Professor, Institute of Low Temperature Science, Hokkaido University)

Studies on Glacier and Snow Cover Variations in South America

Shuhei TAKAHASHI (Professor, Kitami Institute of Technology)

Verification of Satellite Data with Automatic Meteorological Data Station in Polar Regions

Masaki SAWAMOTO (Professor, Tohoku University)

Analysis of Snow Area and Landcover by Satellite Remote Sensing

Takeshi KAWAMURA (Professor, Institute of Geoscience, University of Tsukuba)

Modeling and its application to estomate thermal-hydrological environments over complex terrain using satellite data

Tetsuzo YASUNARI (Associate Professor, Institute of Geoscience, University of Tsukuba)

Satellite Climatological Study of Large Scale Snow Cover over the Northern Hemisphere

Takashi HOSHI (Associate Professor, Institute of Information Science and Electronics, University of Tsukuba)

Estimated Model of Areal Evapotranspiration

Kikuo KATO (Associate Professor, Water Research Institute, Nagoya University)

Study on Transportation Process of Water Vapor by Combining of Satellite Data and Isotope Data of Precipitation

Fumihiko NISHIO (Professor, Hokkaido University of Education)

Ice Front Fluctuation of Shirase Glacier and Dynamical Analysis of Ice Sheet

Heat Budget of Vegetation and Bare Soil

Junsei KONDO (Professor, Geophysical Institute, Tohoku University)

Water and heat balance at the ground surfaces (e.g. vegetated surface, bare soil and snow cover).

Room Experiment of Trace of Soil Moisture by Microwave Remote Sensing

Katsumi MUSHIAKE (Professor, Institute of Industrial Science, University of Tokyo)

Soil moisture measurement by active micro wave remote sensing techniques.

Analysis of Rainfall Mechanism by Satellite and Three - dimensional Radar

Shuichi IKEBUCHI (Professor, Disaster Prevention Research Institute, Kyoto University)

Development of a method of estimating global distributions of conversion rate, latent heat release and wind.

Analysis of Snowfall Phenomena by Satellite Remote Sensing

Toshio KOIKE (Associate Professor, Nagaoka University of Technology)

Study on snowfall using satellite remote sensing and ground - based radar.

Large - scale water cycles and rainfall over the land in East Asia

Kuranoshin KATO (Research Associate, Water Research Institute, Nagoya University)

Large - scale water cycles as climate systems in relation to maintenance processes of precipitation over the continent in East Asia.

Studies on Glacier and Snow Cover Variations in South America

Renji NARUSE (Associate Professor, Institute of Low Temperature Science, Hokkaido University)

The present study analyzes satellite data in order to clarify the characteristics and mechanism of recent glacier and snow cover variations of different types in Patagonia and the high altitude Andes in South America. Landsat data (MSS and TM) are used to determine the positions of glacier termini and to measure the snowcovered areas in different two or three years during 1972 to 1989.

Verification of Satellite Data with Automatic Meteorological Data Station in Polar Regions

Shuhei TAKAHASHI (Professor, Kitami Institute of Technology)

In S ϕr Rone Dane region in the Antarctica, meteorological data Got by data - loggers near Aska Station are collected and analyzed. The data obtained by automatic observation station in other Antarctic regions (contained the data by other countries' party) are collected and its directory is made.

Meteorological data in a wide area of the Antarctic region are compared with satellite

data of LANDSAT, NOAA AND MOS-1, and parameters for interpretation between both data are determined. In the Arctic region, meteorological data at Greenland ice-sheet and Svalbard Islands are also compared with satellite data.

Analysis of Snow Area and Landcover by Satellite Remote Sensing

Masaki SAWAMOTO (Professor, Tohoku University)

Study snowcover area by NOAA-AVHRR and propose a snowmelt runoff model in Okutadami basin.

Modeling and its Application to Estimate Thermal-hydrological Environments over Complex Terrain Using Satellite Data

Takeshi KAWAMURA (Professor, Institute of Geoscience, University of Tsukuba)

The purpose of this study is the establishment of the estimation method of actual evapotranspiration in the basin, due to combine the data of surface coverage, suface meteorological elements and topography.

Satellite Climatological Study of Large Scale Snow Cover over the Northern Hemisphere

Tetsuzo YASUNARI (Associate Professor, Institute of Geoscience, University of Tsukuba)

Snow mass over the continets are calculated from ground observed temperature and precipitation data and are compared with the SMMR satellite derived snow depth data.

Estimated Model of Areal Evapotranspiration

Takashi HOSHI (Associate Professor, Institute of Information Science and Electronics, University of Tsukuba)

In order to estimate aveal evapotranspiration, a model based on the modified Penman method was developed. The model can be used in the Tropics and Temperate zones except Frigid/Plan zones. The study add the element of the heatfusion to the model which makes it possible to estime the areal evapotransperation in the Frigid/Polan zones.

Study on Transportation Process of Water Vapor by Combining of Satellite Data and Isotope Data of Precipitation

Kikuo KATO (Associate Professor, Water Research Institute, Nagoya University)

Satellite data and isotope data of precipitation are combined for study on transportation process of water vapor. Stable isotopic composition of precipitation is mainly controlled by transportation process of water vapor. So, through study on the relations between variations of snow-cover area and vegitation activity shown from processing of satellite data and stable isotopes data of precipitation, to solve the transportation process of water vapor is planned.

Ice Front Fluctuation of Shirase Glacier and Dynamical Analysis of Ice Sheet

Fumihiko NISHIO (Professor, Hokkaido University of Education)

In the region of the mouth of fast - moving ice stream of Shirase Glacier, the Coast line of ice sheet and terminus of glaciers will be determined by the satellite image data of MOS - 1 and SPOT. The rate of calving from ice sheet and number of icebergs will be al - so determined by these image data. This year satellite altimeter data such as SEASAT and GEOSAT will be analyzed for the thinning of Shirase Glacier drainage basin to compare the ground survey data. The mass balance in the region of Shirase Glacier drainage basin will be estimated by suface snow accumulation, movement of ice sheet, ice thickness and output of Shirase Glacier flow based on satellite image data.

Group D: Study of Air - Sea Interaction Using Satellite Data

Head Investigator

Yasuhiro SUGIMORI (Professor, School of Marine Science and Technology, Tokai University)

Basic Research on Flux Estimation between Air and Ocean

Investigators

Norihisa IMASATO (Professor, Faculty of Science, Kyoto University)

Basic Research on Flux Estimation between Air and Ocean

Hiroshi KAWAMURA (Associate Professor, Faculty of Science, Tohoku University)

Basic Research on Flux Estimation between Air and Ocean

Ryuji KIMURA (Associate Professor, Ocean Research Institute, University of Tokyo)

Research on Application of Satellite Data to Atmospheric Process

Tsutomu TAKASHIMA (Head, Meteorological Research Institute)

Research on Application of Satellite Data to Atmospheric Process

Yoshinobu WAKATA (Associate Professor, School of Marine Science and Technology, Tokai University)

Research on Application of Satellite Data to Atmospheric Process

Yasuhiro SENGA (Associate Professor, School of Marine Science and Technology, Tokai University)

Estimation of suspended and dissolved matters from underwater irradiance spectra

Masahisa KUBOTA (Associate Professor, School of Marine Science and Technology, Tokai University)

Study of the Variability of Sea Surface Fluxes

Toshiyuki AWAJI (Associate Professor, Faculty of Science, Kyoto University)

Analysis of water mass formation and its variability using thermal infrared imagery

Kunio KUTSUWADA (Research Associate, Otsuchi Marine Research Center, Ocean Research Institute, University of Tokyo)

Study on Estimations of Large - Scale Momentum Flux Field over Open Ocean

Momoki KOGA (Associate Professor, Faculty of Sciences, University of the Ryukyus)

Remote sensing of sea surface heat flux in the beginning of the Kuroshio

Takashige SUGIMOTO (Professor, Ocean Research Institute, University of Tokyo)

Observation and Satellite Image Analyses of Primary Production Environments in Surrounding Area of the Kuroshio and Oyashio

Shiro IMAWAKI (Associate Professor, Faculty of Fisheries, Kagoshima University)

Study of fluctuation of the sea surface topography in the North Pacific using GEOSAT altimeter

Kozo NAKAMURA (Research Associate, Ocean Research Institute, University of Tokyo)

Estimate of precipitable water over ocean based on satellite data

Yasumasa KODAMA (Research Associate, Faculty of Science, Hirosaki University)

An observational study on the low-level-clouds over the Sea of Okhotsk and the western North Pacific during the warm season with satellite-cloud-images

Hajime FUKUSHIMA (Associate Professor, School of High-Technology for Human Welfare, Tokai University)

Evaluation of Atmospheric Effect in Visible Bands of NOAA/AVHRR Data

Mitsuo UEMATSU (Associate Professor, Hokkaido Tokai University)

Distribution and Deposition Rate of Mineral Aerosols over the North Pacific from the Satellite Image

Toshiro SAINO (Research Associate, Ocean Research Institute, University of Tokyo)

Responses of biological processes to changes of the oceanic conditions monitored by visible and infra-red satellite images

Sonoyo MUKAI (Professor, Kinki University)

Atmospheric Correction and Ocean Color Remote Sensing

Study of Air-Sea Interaction Using Satellite Data
Basic Research on Flux Estimation between Air and Ocean

Yasuhiro SUGIMORI (Professor, School of Marine Science and Technology, Tokai University)

Norihisa IMASATO (Professor, Faculty of Science, Kyoto University)

Hiroshi KAWAMURA (Associate Professor, Faculty of Science, Tohoku University)

Yoshinobu WAKATA (Associate Professor, School of Marine Science and Technology, Tokai University)

Research Plan

(1) Techniques to estimate air-sea fluxes by satellite data will be developed using the satellite data and in-situ data. The spatial distribution of heat flux in wide area will be determined (Sugimori, Wakata). Satellite observation of sea surface temperature and atmospheric moisture will be studied (Kawamura).

(2) Observations in Tanabe Bay will be continued for understanding the relation between oceanographic mixed structure of the skin-layer near sea surface and heat-flux through the sea surface (Imasato). The short term variations of ocean mixed layer will be analyzed using satellite data (Sugimori).

Study of Air-Sea Interaction Using Satellite Data
Research on Application of Satellite Data to Atmospheric Process

Ryuji KIMURA (Associate Professor, Ocean Research Institute, University of Tokyo)

Tsutomu TAKASHIMA (Head, Meteorological Research Institute)

Research Plan

Air-mass modification process in an cold air outbreak over the Eastern China Sea is investigated by GMS and a heat budget calculation based on observational data obtained by a meteorological buoy operated by JMA (Kimura). A simulation program of radia-

tive transfer calculation for an atmosphere - ocean model including cirrus cloud and broken cloud will be developed. Solar radiation at the surface will be measured using pyranometers and a sunphotometer (Takashima).

Study of Air - Sea Interaction Using Satellite Data

Estimation of suspended and dissolved matters from underwater irradiance spectra

Yasuhiro SENGA (Associate Professor,
School of Marine Science and Technology, Tokai University)

Research Plan

Algorithms to estimate the vertical distribution of both suspended matters including phytoplanktons and dissolved matters by using underwater irradiance spectra will be developed. The relation between these distributions and satellite data will be also investigated (Senga).

Study of the Variability of Sea Surface Fluxes

Masahisa KUBOTA (Associate Professor,
School of Marine Science and Technology, Tokai University)
Naoto IWASAKA (Associate Professor, Tokyo University of Merchantile Marine)

Research Plan:

(1) Mapping of GEOSAT wind data over the North Pacific from 1985 to 1989.

(2) Analysis and intercomparison of GEOSAT wind data and other wind data.

(3) Estimation of heat flux over the North Pacific by using COADS and ECMWF.

(4) Investigation of variability of Bowen ratio.

Analysis of Water Mass Formation and its Variability Using Thermal Infrared Imagery

Toshiyuki AWAJI (Associate Professor,Faculty of Science, Kyoto University)

Research Plan:

The main goal of this study is to understand the physical process of water mass formation and its variability in the western part of the North Pacific. For this purpose, we perform numerical experiment focusing on seasonal variations in the Kuroshio and the Kuroshio Extension. We also perform the Lagrangion tracking of water particles. The result is compared with satellite imagery to reveal the transport mechanism which significantly affects the water mass formation and its variability.

Study on Estimations of Large-Scale Momentum Flux Field over Open Ocean

Kunio KUTSUWADA (Research Associate, Otsuchi Marine Research Center, Ocean Research Institute, University of Tokyo)

Plan:

The main part of our study in this year is to derive a reliable momentum flux field over the Pacific Ocean using the following procedures:

(1) We get as many as possible surface meteorological data over the Pacific Ocean from the Japan Meteorological Agency and the National Climatic Center in USA, and estimate surface momentum flux fields in various time means(e.g. monthly and bi-monthly). Further, we compare results based on different empirical formula, and examine the reliability of surface momentum fluxes quantitatively.

(2) We compare the above results with those derived by some later studies, and get a complete data set of surface momentum flux field over the Pacific Ocean.

(3) We get surface momentum flux fields which were estimated from microwave satellite data. By comparing those with the flux fields based on sea truth data, we investigate the reliability of the estimations based on satellite data.

Remote Sensing of Sea Surface Heat Flux in the Beginning of the Kuroshio

Momoki KOGA (Associate Professor, Faculty of Sciences, University of the Ryukyus)
Suguru ISHIJIMA (Professor, Junior College, University of the Ryukyus)

Research Plan:

(1) Field observations

We continue the automatic measurement of the sea surface heat flux (bulk method) from the ferryboat between Okinawa and Taiwan. The measurement was started in October last year, so the successive data set longer than one year will be available for our analysis. We will have some additional observations from the ferryboat using a portable radiometer and XBT to investigate the temperature conditions of the sea surface and the ocean mixed layer.

(2) Satellite data and data analysis

We examine the data from GMS and NOAA Satellites in relation to our field data (sea truth data). We try to derive an empirical formula useful in our study area for the surface heat flux estimation using satellite data. In order to clarify the temperature condition in the heat flux estimation, we also examine how the sea surface temperature by the portable radiometer is related to the sub-surface temperature.

Study of Fluctuation of the Sea Surface Topography in the North Pacific Using GEOSAT Altimeter

Shiro IMAWAKI (Associate Professor, Faculty of Fisheries, Kagoshima University)

Plan:

We will analyze the time series of the sea surface dynamic topography (the departure of the actual sea surface from the geoid, the departure which is related with the geostrophic velocity at the sea surface) in the central and western North Pacific (0-55 deg. N, 120 deg. E-170 deg. E) based on GEOSAT altimetry data, the time series which was prepared last year. We will discuss temporal fluctuations of the Kuroshio Extension and the North Pacific Current as well as characteristics of mesoscale fluctuations. We will compare the obtained time series with tide gauge data at islands in the North Pacific to assess how successfully the time series describes the in situ low frequency sea level fluctuations. Those results will be published.

Estimate of Precipitable Water over Ocean Based on Satellite Data

Kozo NAKAMURA (Research Associate, Ocean Research Institute, University of Tokyo)
Hirotaka OTOBE (Ocean Research Institute, University of Tokyo)

Research Plan:

The physical quantities controlling the precipitation, such as precipitable water content, condensed water content, and precipitation intensity estimated by a conventional method with satellite data are compared with the ground-truth based on radio sonde, radar, and AMeDAS data. Observations of precipitation on board of a research vessel "Hakuho-maru" and upper-air soundings with the Omega-sonde system are also performed to investigate the validity of the conventional method.

An Observational Study on the Low-level-clouds over the Sea of Okhotsk and the Western North Pacific during the Warm Season with Satellite-cloud-images

Yasumasa KODAMA (Research Associate, Faculty of Science, Hirosaki University)
Kunio RIKIISHI (Associate Professor, Faculty of Science, Hirosaki University)

Study Plan:

Continued on last year, we will develop the methods to stimate seasurface long-wave and short-wave radiations by GMS Low-Resolution-fax images.

Using three year LR-fax images since 1988, we will investigate longterm variations of radiative fluxes over the Sea of Okhotsk and the western North Pasific during the summer, and discuss the ralationships between these variations and SST variations.

Evaluation of Atmospheric Effect in Visible Bands of NOAA/AVHRR Data

Hajime FUKUSHIMA (Associate Professor,
School of High - Technology for Human Welfare, Tokai University)

Research Plan:

Lacking ocean color satellite observation currently in operation, the use of visible channel data of NOAA/AVHRR is worth trying in order to estimate sea - surface reflectance and its spatial variability. AVHRR visible channel data will also be useful in terms of detection of low - altitude clouds which may affect the aparent AVHRR - derived SST field. Obviously, to estimate reflectances at ocean surface precisely, the atmospheric effect should be properly evaluated and removed. The study is to introduce the Gordon's scheme, which has been widely used for Nimbus - 7/CZCS atmospheric correction, for AVHRR visible channel data.

The research plan for this year is as follows.

(1) Documents and papers regarding sensitivity calibration of AVHRR visible bands will be collected and studied.

(2) The effects of optically absorbing gas will be evaluated using LOWTRAN code.

(3) Program for evaluating atmospheric effect in AVHRR visible channels will be developed. At first, the single scattering Rayleigh model will be implemented. The multiple scattering and polarization effect may be considered for late implementation.

(4) Data set of about 10 AVHRR data from different seasons will be collected. It will be then processed by the developed software for adjusting various parameters such as calibration factors and the solar constant. Finally, the validity of sensor calibration and the radiative transfer model will be evaluated.

Responses of Biological Processes to Changes of the Oceanic Conditions Monitored by Visible and Infra - red Satellite Images

Toshiro SAINO (Associate Professor, Ocean Research Institute, University of Tokyo)

Research Plan:

To continue analysing the case of regional upwelling. Emphasis will be placed on the relationship between patterns of sea surface temperature field and phytoplankton pigment distribution. Contribution of upwelling events to the productivity in the region around the Izu Islands is to be estimated.

To start analysing the case of winter convective overturn in the northern North Pacific. Seasonal change of the phytoplankton pigment field will be traced by the CZCS monthly composite level 3 data. Based on the hydrographic data, annual input of nitrate to the euphotic zone will be estimated, and the annual new production will be estimated.

Atmospheric Correction and Ocean Color Remote Sensing

Sonoyo MUKAI (Professor, Kinki University)

Research Plan:

Bio-optical algorithms relate the ocean color data in the visible wavelengths to the concentration of phytoplankton pigments near the sea surface. In marine remote sensing in the visible region, the intensity of radiation from the ocean is roughly one tenth of the total intensity observed at a space borne sensor. This is mainly caused by multiple scattering in the Earth's atmosphere. Therefore, removal of such a scattering effect from the original data, what one calls atmospheric correction, is necessary to get significant information of the ocean.

This work shows an atmospheric correction procedure for ocean color remote sensing on the basis of multiple scattering calculations in an atmosphere-ocean model. Chlorophyll density distribution near the sea surface is derived from CZCS data by our treatment. The results are compared with and/or applied to environmental information of the ocean.

Group E: Advanced Data Processing and Data Base Techniques for Earth Observation

Head Investigator

Ryuzo YOKOYAMA (Professor, Faculty of Engineering, Iwate University)

Development of Temporal and Spatial Models and Simulation Techniques for Environmental Phenomena Based on Earth Observation Data

Investigators

Teruhisa SHIMODA (Professor, Tokai Research and Information Center, Tokai University)

Development of Integrated Image Interprtation System Based on Artificial Intelligence Methods

Mikio Takagi (Professor, Institute of Industrial Science, University of Tokyo)

Development of Efficient Data Base System for Earth Observation Data

Yoshizumi YASUDA (Professor, Faculty of Engineering, Chiba University)

Development of Efficient Data Base System for Earth Observation Data

Takashi MATSUYAMA (Professor, Faculty of Engineering, Okayama University)

A Study on Multi-Source Analysis Algorithms for Remote Sensing Imagery

Sadao FUJIMURA (Professor, Faculty of Engineering, University of Tokyo)

Study on Hierarchical Processing of Remotely Sensed Images

Masao SAKAUCHI (Professor, Institute of Industrial Science, University of Tokyo)

Research on High-level Image Processing in Remote Sensing Fields Using Geographic Database as Support Knowledge

Yoshiyuki KAWATA (Professor, Information Science Laboratory, Kanazawa Institute of Technology)

Feature Extraction for Forest from Rugged Terrain Image Based on Atmospheric and Topographic Correction

Takashi KUSAKA (Professor, Kanazawa Institute of Technology)

Recognition of satellite imagery using digitized map data and its application

Yoshio YOSHIDA (Professor, National Institute of Polar Research)

Geomorphological Studies of Antarctic Inland-outcropped Areas using GEOSAT Radar Altimeter and LANDSAT TM Data

Advanced Data Processing and Data Base Techniques for Earth Observation
Development of Integrated Image Interprtation System Based on Artificial Intelligence Methods

Teruhisa SHIMODA (Professor, Tokai Research and Information Center, Tokai University)

In this study, an advanced classification algorithm for land covers and land uses by using both the spectral and the spatial informations have been develoed, and an expert system for image interpretation of the remotely sensed data has been developed. In this

year, the validation tests of their efficiencies will be proceeded.

Advanced Data Processing and Data Base Techniques for Earth Observation
Development of Temporal and Spatial Models and Simulation Techniques for Environmental Phenomena Based on Earth Observation Data
Ryuzo YOKOYAMA (Professor, Faculty of Engineering, Iwate University)

Development of mathematical modelling techniques for spatial and temporal phenomena of environment, conducted by Prof. Yokoyama: In this study, A new runoff model called "mesh type runoff model" has been developed based on the remotely sensed data and the geographical informations. By using the observation data at the Kitakami River Flood Control Office in Japan, the accuracy of the model has been evaluated to show excellent results. In this year, further improvements for the parameter determination algorithm will be done.

Advanced Data Processing and Data Base Techniques for Earth Observation
Development of Efficient Data Base System for Earth Observation Data
Mikio Takagi (Professor, Institute of Industrial Science, University of Tokyo)
Yoshizumi YASUDA (Professor, Faculty of Engineering, Chiba University)

In this study, two topics, a data compression method and a construction of an efficient data base system, are conducted. The objects are the images of the SST and the vegetation index derived from NOAA-AVHRR images. For the data compression algorithms, various techniques in the statistics, such as the principal component analysis and the histogram analysis will be applied for the feature extractions of the images. The fundamental algorithms have been developed. In this yearthe system validation tests will be conducted at the final stage.

A Study on Multi-Source Analysis Algorithms for Remote Sensing Imagery
Takashi MATSUYAMA (Faculty of Engineering, Okayama University)

Based on the studies the last two years, we will conduct the following researchers.

(1) Based on the Dempster & Shafer's probability model, we will develop the following algorithms for the multi-source analysis. The study will be done mainly from a theoretical viewpoint, and some experiments will be conducted to show the utility of integrating spectral and spatial information.
- to compute a belief function based on histograms of training samples or similarity measures between standard patterns and an observed pattern
- to integrate multiple belief functions, especially those including internal conflicts
- to make a final decision based on the integrated belief function.

(2) We have almost finished the implementation of an image processing /display soft-

ware system in C++ on 24 bit full color workstation, SUN3/80. We will develop an improved version of the software and install it on SUN4.

Study on Hierarchical Processing of Remotely Sensed Images

Sadao FUJIMURA (Professor, Faculty of Engineering, University of Tokyo)
Yoshihumi YASUOKA (Head, National Institute for Environmental Studies)
Hiroshi HANAIZUMI (Associate Professor,
Hosei University, Faculty of Engineering)

Research Plan:

1. Development of an automatic registration algorithm
2. Detection and extraction of altered area from multi - temporal images
3. Discussion on introducing a priori information into sensing & processing

Research on High - level Image Processing in Remote Sensing Fields Using Geographic Database as Support Knowledge

Masao SAKAUCHI (Professor, Institute of Industrial Science, University of Tokyo)
Heitou ZEN (Research Associate, Institute of Industrial Science , University of Tokyo)

Research Plan:

Research targets of this project are to develop new knowledge - based image understanding systems for various type of maps and remotely - sensed images with geographical databases.

In this fiscal year, following subtargets are set.

1. The 1/25000 Japanese base map image understanding system and airplane remotely - sensed image understanding system, whose basic ideas were developed in the last fiscal year, will be improved after considering the performance for another types of areas.
2. The knowledge - base for understanding various maps and remotely - sensed images will be extended.
3. Towards the geographical media fusion, analysis method of aerial image using the knowledge from map reading, will be studied.
4. Multiple evaluation experiments will be performed on the above system, and if necessary, the system will be improved.

Feature Extraction for Forest from Rugged Terrain Image Based on Atmospheric and Topographic Correction

Yoshiyuki KAWATA (Professor, Information Science Laboratory, Kanazawa Institute of Technology) Cooperator
Sueo UENO (Emeritus Professor, Information Science Laboratory, Kanazawa Institute of Technology)

Outline of Research

1. In this research we are going to develope a 3 dimensional Monte Carlo Simulation Code which is applicable to the radiative problems with complicated boundary conditions.

2. The digital terrain data is required to obtain the realistic topographic boundary condition. We try to make the digital terrain data for our study area by using an extraction system of terrain elevation data from topographic map. Such a system is also being developed in this study. Then, numerical simulations will be made by using the Monte Calro code for the study site.

3. In the next, we try to evaluate each of radiance components within the observed radiance by the simulation results. Finally, we try to find a method to estimate mean albedo values and characteristic parameters in reflection law for different forest types.

Recognition of Satellite Imagery Using Digitized Map Data and its Application

Takashi KUSAKA (Professor, Kanazawa Institute of Technology)
Masaaki SIKADA (Instructor, Kanazawa Institute of Technology)
Kei MIYAKITA (Professor, Kanazawa Institute of Technology)

Research plan

The aim of this research is to develop advanced techniques for recognizing the desired objects and structures in satellite remote sensing images. The Map-Assisted image Recognition System (MARS), is developed in this study. The MARS system utilizes an Image-Map database system including satellite images, digital terrain and digitized thematic maps.

The following is a brief description of the major components of the MARS system.

(1) Region extraction and image recognition processing

(i) A method for segmenting satellite images into small regions that have nearly uniform color is developed, based on an edge-based segmentation technique.

(ii) The hierarchical recognition scheme is used in the MARS system. We first recognize the regions with outstanding properties such as large extended areas and thin elongated regions by using the Image-Map database system and then investigate the detailed structures in the underlying image.

(2) Applications

An Image-Map database system, which contains satellite images, digital terrain model and digitized thematic maps, is constructed. The MARS system is applied to in-

vestigate the characteristic properties in landslide areas.

Geomorphological Studies of Antarctic Inland - outcropped Areas Using GEOSAT Radar Altimeter and LANDSAT TM Data

Yoshio YOSHIDA (Professor, National Institute of Polar Research)
Kazuo SHIBUYA (Associate Professor, National Institute of Polar Research)

Research plan

1. Based on two years' analysis of GEOSAT data, we plan to refine surface topographic map of the Antarctic ice sheet around the Yamato Mountains. We consider the followings in the data analysis.
   (i) As ground tracks of ERM data were sparse, Geodetic Miss-ion data are to be included.
   (ii) 20-km gridded elevation data yielded fictitious rugged surface topography, so that we plan to make 10-km gridded meshes with the inclusion of control points by the aerophotographic surveys.
   (iii) There remained 10-30 m inconsistency between the ground height data by satellite surveying and GEOSAT ERM derived altimeter height. Optimum adjustment of cross over errors for the Geodetic Mission data are continued.
   (iv) Brightness temperature ranges from -16℃ on moraine area to -24℃ in snow accumulated area. Isothermal maps (2℃ interval) will be made based on DN values and compared with the stretched scene.
   (v) Detection of lineaments which are associated with shears on the ice surface will be tried by a filtering method.
2. Geomorphological discussions will be made using the obtained 3D imagery.

JERS-1

Data Acquisition and Distribution

HIROSHI ISHIGAMI

REMOTE SENSING TECHNOLOGY CENTER OF JAPAN

1. System Overview

The JERS-1 system consists of a space segment and a ground segment. The space segment is the JERS-1 satellite itself. The ground segment includes the tracking and control function, data acquisition and processing functions, and the Mission Management Organization (MMO). The overall configuration of the JERS-1 system is shown in Fig. 1-1.

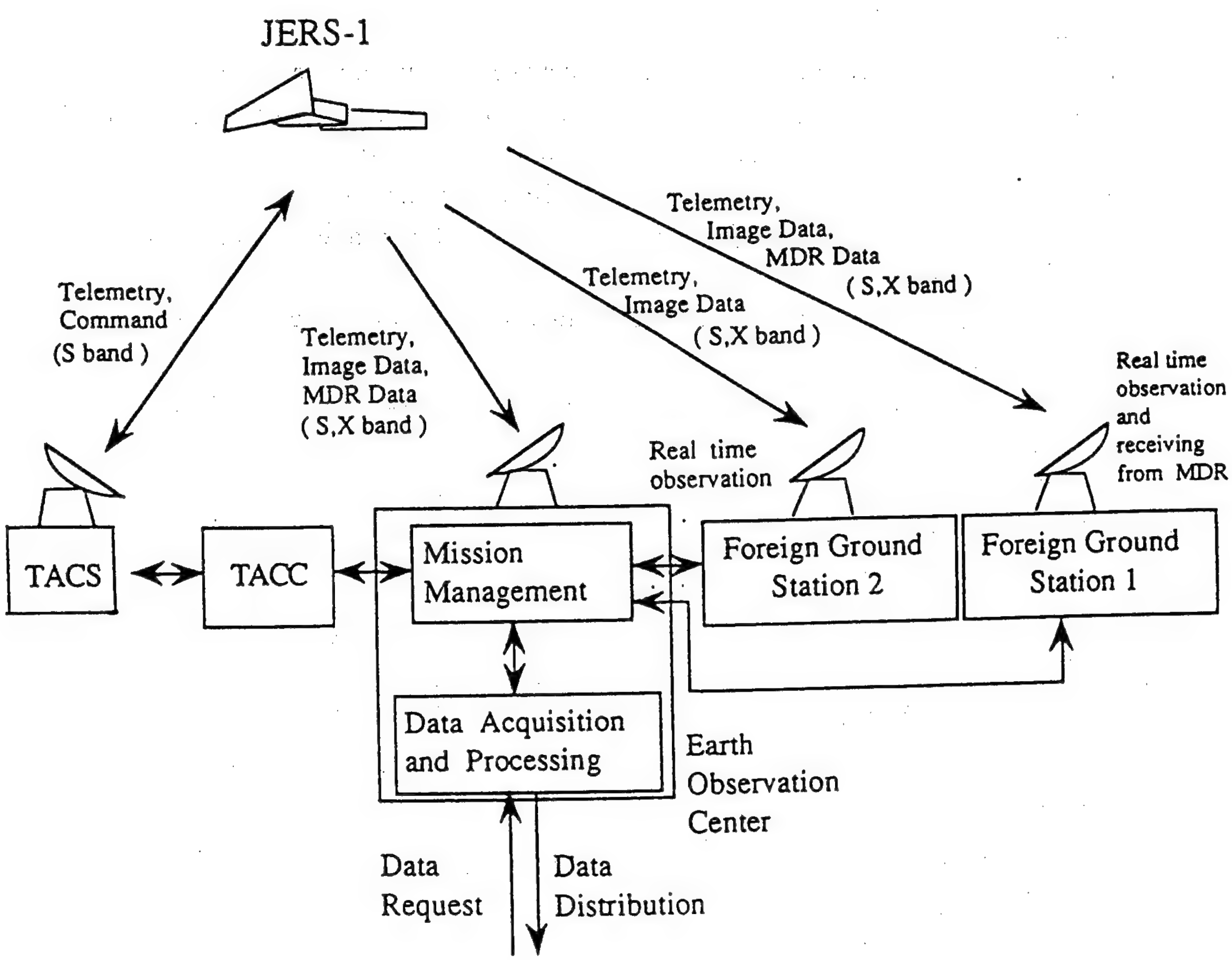


Fig. 1-1 Configuration of JERS-1 Total System

2. Satellite

The satellite consists of a bus section and a mission section. The bus section contains the basic satellite equipment including the electrical power supply and attitude control functions. The mission section consists of the synthetic aperture radar (SAR), optical sensor (OPS), mission data transmitter (MDT) and mission data recorder (MDR). An overview of the JERS-1 is shown in Fig. 2-1, and the principal specifications in Table 2-1.

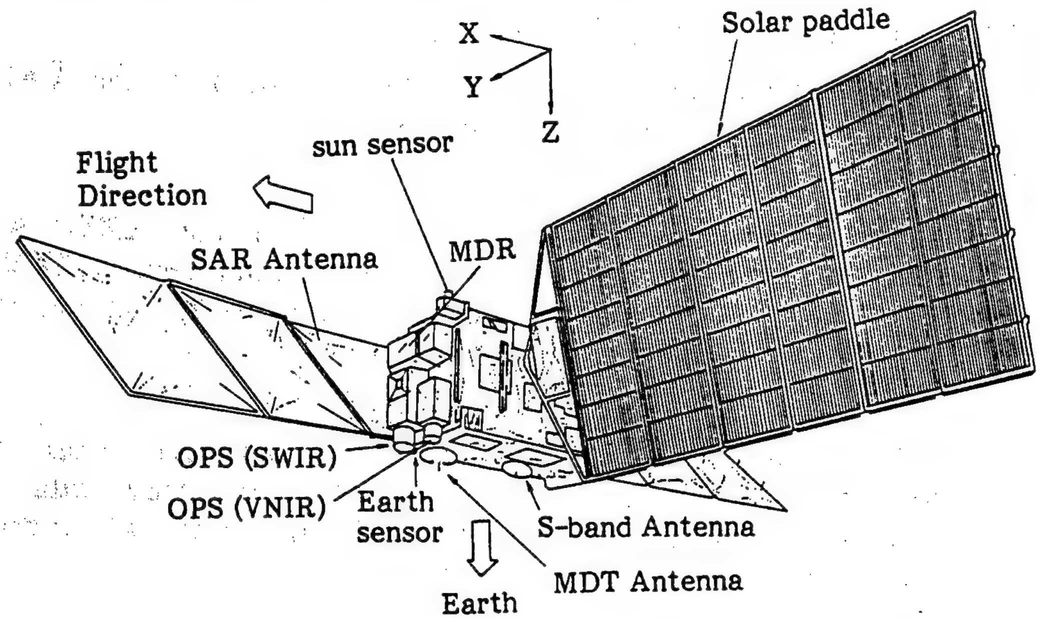


Fig. 2-1 Artist's View of JERS-1

Table 2-1 Characteristics of JERS-1

Shape	Body Approx. 1m × 1.8m × 3.1m Boxtype Synthetic aperture rader Approx. 12m × 2.5m Solar cell paddle Approx. 8m × 3.4m
Weight	Approx.1.4 t
Attitude control	Three-axis stabilized Zero momentum
Mission Life	2 years
Launch vehicle	H - I (2-stage)
Launch site	Tanegashima Space Center
Launch date	February, 1992

3. Ground Segment

3.1 Tracking and Control

Tracking and control of the JERS-1 will be performed by the Tracking and Control Center (TACC) at Tsukuba Space Center and by the Tracking and Control Stations (TACSs) at Katsuura, Tanegashima, Okinawa and overseas station Kiruna (Sweden).

3.2 Data Acquisition and Processing

The data acquisition and processing functions at the Earth Observation Center (EOC) are as follows:

(1) Reception and recording

Observed data and telemetered data from the JERS-1 are received and recorded on high density digital tape (HDDT). In addition, quick look images are created and stored on optical disks (ODs) with regard to the OPS.

(2) Processing

Based on observed data and telemetered data, necessary corrections will be applied, and the processed data is obtained in form of a OD, CCT and film as output produsts.

(3) Inspection and evaluation

Products created by the processing facilities are to be inspected, and the accuracy of the corrections is to be evaluated.

(4) Storage, retrieval and distribution

The created CCTs, ODs and films are to be stored. They are to be retrieved and distributed in response to requests from users.

The relationships among the above functions are shown in Fig. 3-1.

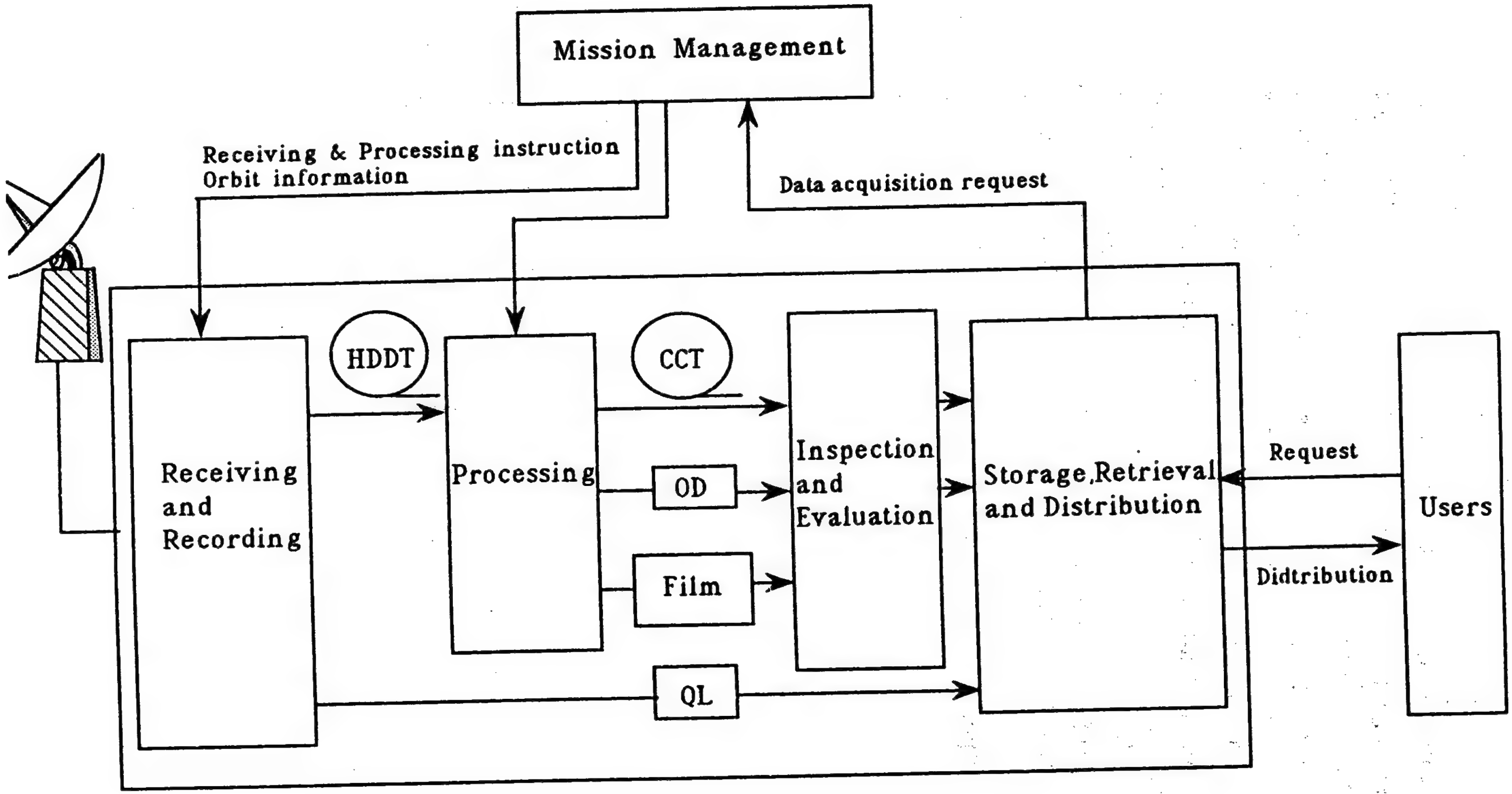


Fig. 3-1 Outline of Data Acquisition and Processing Facilities

3.3 Mission Management Organization

Mission management organization (MMO) by the EOC includes the following functions:

(1) To coordinate requests from users and ground stations, and send mission operation requests to TACC, and receive operation plans, orbit information, etc. from TACC.

(2) To send operation plans and orbit information to the ground stations, and receive the status of observation from them.

(3) To perform primary evaluation of the mission instruments from telemetry data acquired from the EOC.

The flow of operation planning is shown in Fig. 3-2.

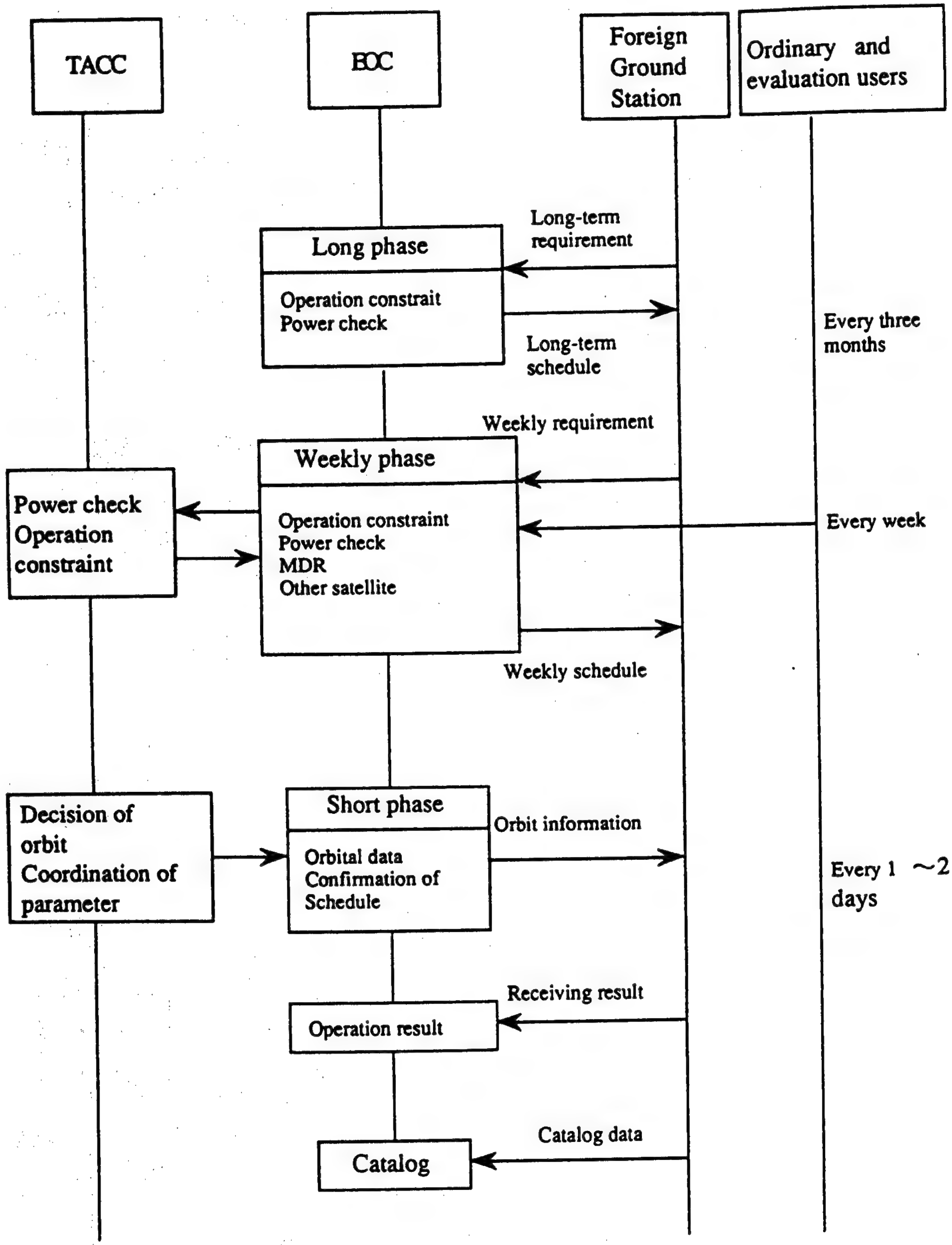


Fig. 3-2. Decision Flow of Mission Operation Schedule

4. Orbit and Coverage

4.1 Orbit

The steady-state orbit of JERS-1, like that of MOS-1, is a west-transition sun synchronous subrecurrent orbit. Its height is 568 km, somewhat lower than that of previous satellites.

JERS-1 will circle around the earth 15 times in 1 day; it will scan the entire earth's surface leaving no gaps once per 44-day cycle.

The orbit parameters of JERS-1 are shown in Table 4-1, and the daily orbit tracks in Fig. 4-1.

Table 4-1 Orbit Parameter

Parameter	Value
Altitude	568.023 km
Semi major Axis	6946.165 km
Inclination	97.662 deg.
Period	96.146 min.
Eccentricity	less than 0.0015
Coverage cycle duration	44 days
Revolution per day	15 - 1/44 rev.
Drift Direction	Westward
Local mern solar time at descending node	10:30 - 11:00 a.m.

4.2 Coverage

JERS-1 has a Mission Data Recorder, and can obtain observational data from the entire earth's surface except for parts of the Arctic and Antarctic.

The JERS-1 receiving stations and visible range from which data can be received in real time are shown in Fig. 4-2.

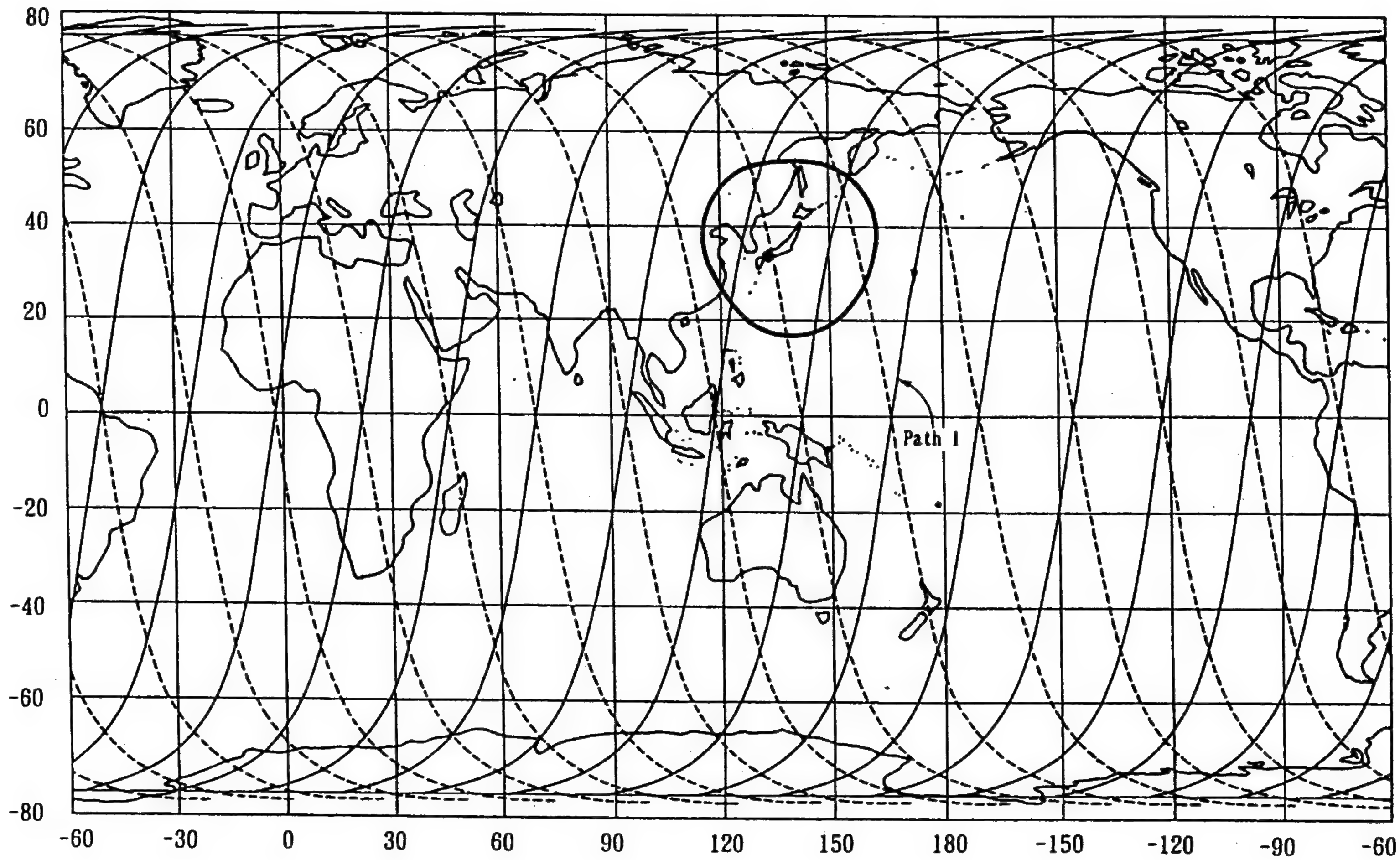
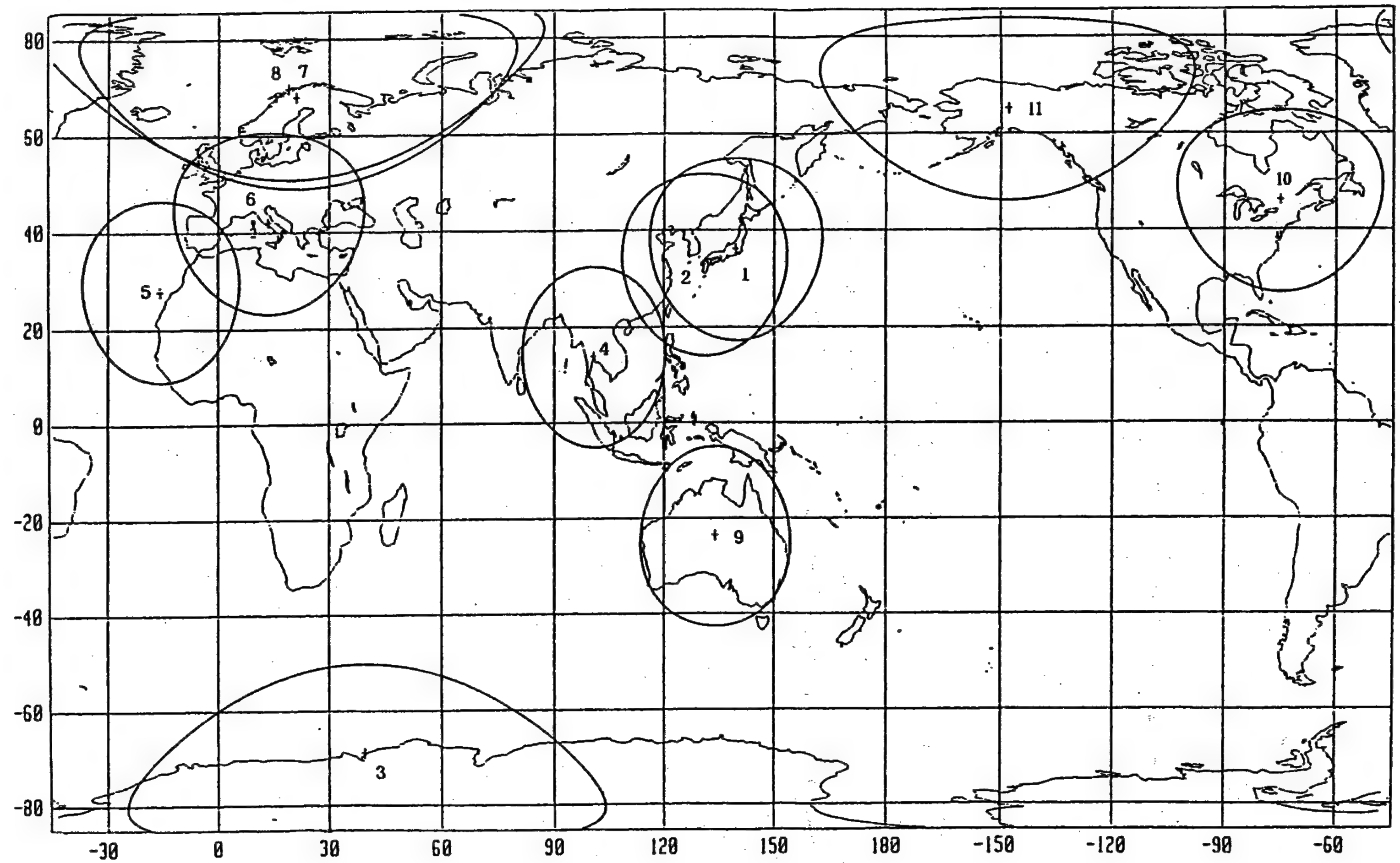


Fig. 4-1 Single Day Orbital Ground Traces

(Path = 1, 45, 89, —, 573, 617)



1 : EOC 2 : Tokai Univ. 3 : Showa Base 4 : Bangkok 5 : Masparomas 6 : Ficino
7 : Kiruna 8 : Toromso 9 : Alice Springs 10 : Gatineau 11 : Fairbanks

Fig. 4-2 JERS-1 Receiving Station and Visible Range (EL = 5^{o})

4.3 Ground Reference System

A Ground Reference System (GRS) is defined to fix the positions of the images obtained by the sensors on the JERS-1.

An outline of the GRS is as follows:

1) The earth is divided into the north polar region, north latitude region, mid latitude region, south latitude region and south polar region.

2) Grids having nearly uniform intervals are defined in each of these regions.

3) Each grid point is represented by 2 integers, the PATH and the ROW numbers.

4) The system is defined only for descending orbits, in order to preserve the uniqueness of the GRS over the entire earth.

5) Except for the north polar and south polar regions, user himself can estimate the date of observation.

6) The grids in the north polar and south polar regions are set parallel to latitude and longitude. In other regions, grid points are determined by thinning-out processing of descending orbits.

The division of the earth into regions is shown in Fig. 4-3, and the relationship between scene and path/row in Fig. 4-4.

The region that is visible at the Earth Observation Center (when receiving in real time) is shown in Fig. 4-5.

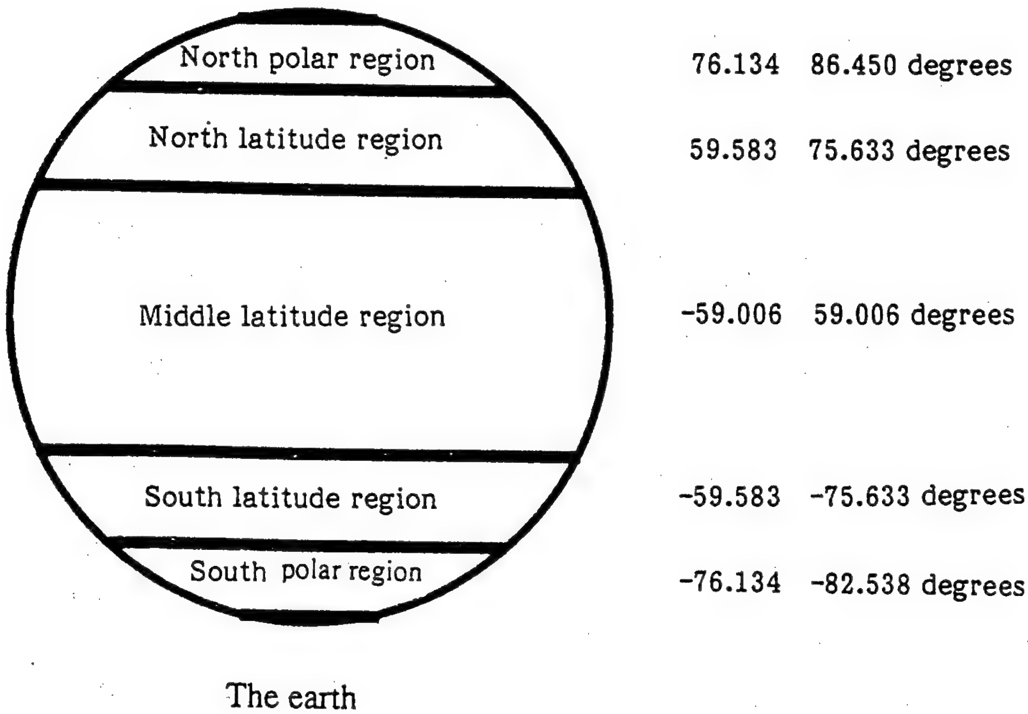


Fig. 4-3. Ground Partition in GRS

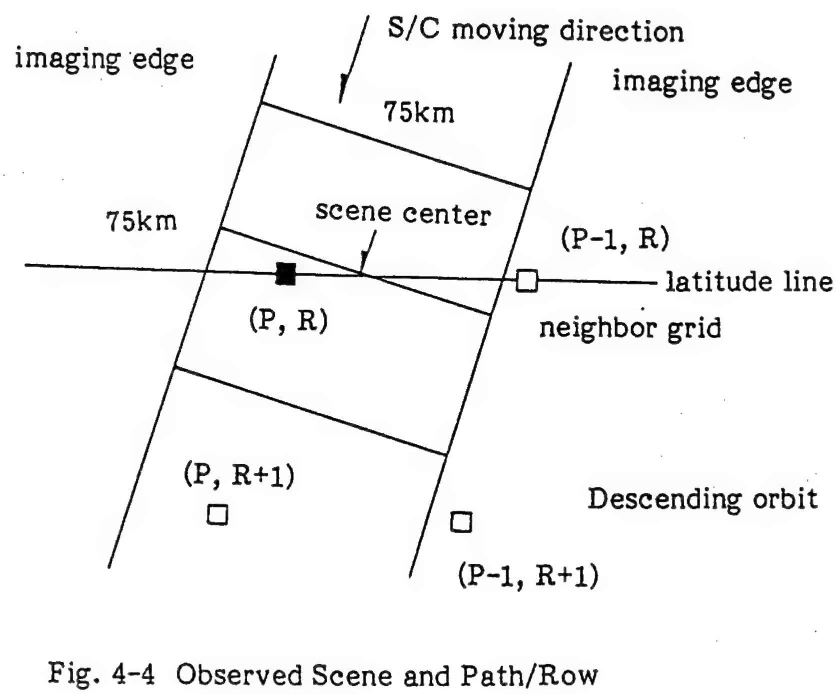


Fig. 4-4 Observed Scene and Path/Row

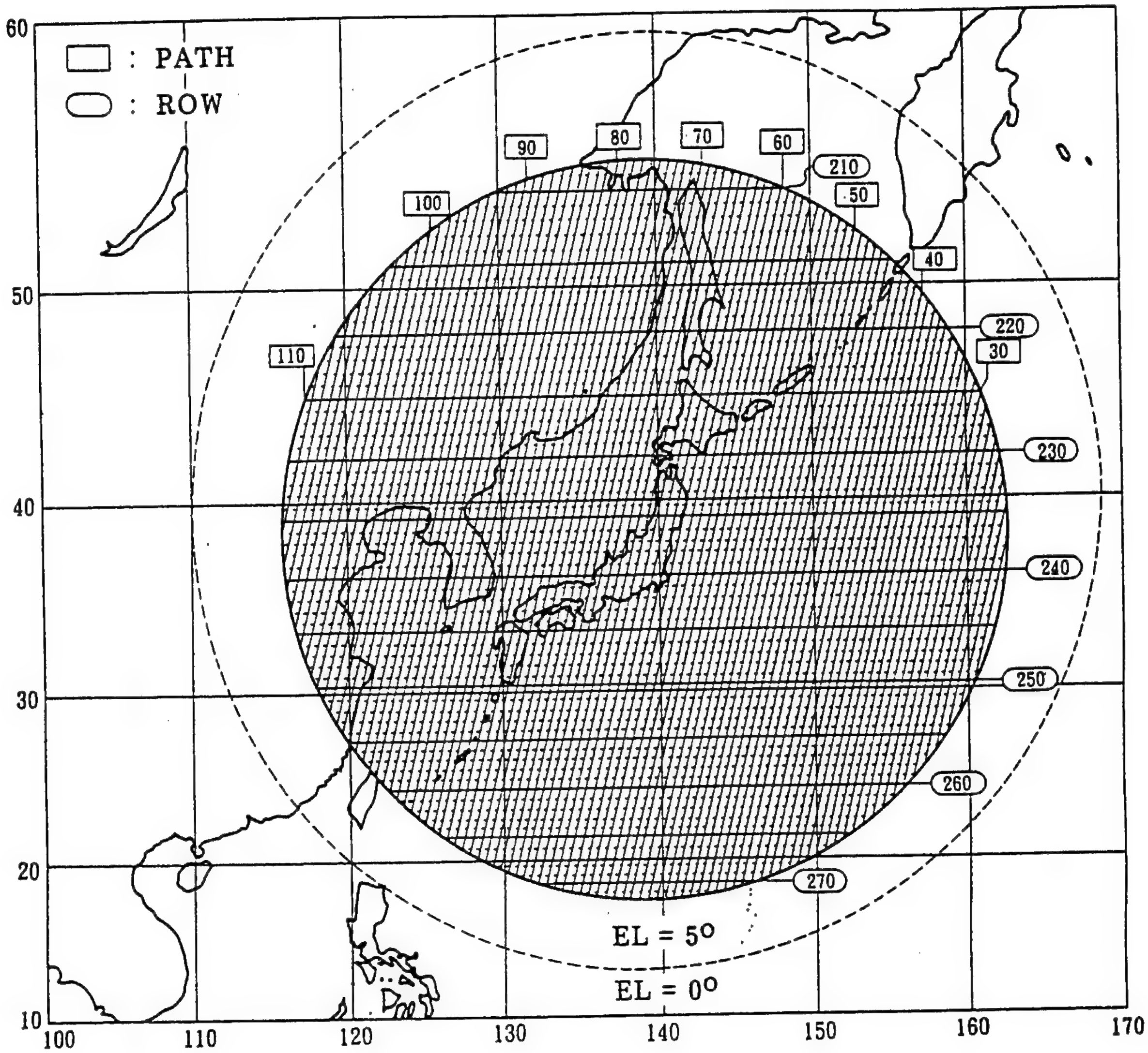


Fig. 4-5 GRS and Visible Range from EOC

5. Mission Instruments

5.1 Synthetic Aperture Radar

Synthetic aperture radar (SAR) emits electromagnetic waves perpendicular to the direction of forward motion of a flying body, as shown in Fig. 5-1. The emitted waves are reflected by objects, and the scattered back radiation is received. The scattering coefficient of an object is determined by the condition and physical properties of the surface of the object and the inside state near the surface of the object. Consequently, by measuring the scattering coefficient of an object, informations about it are obtained. In contrast to ordinary radar, for which the distance resolution and azimuth resolution are determined by the transmission pulse width and azimuthal beam width. In SAR, the processing is decomposed into processing in the range direction (perpendicular to the direction of advance of a flying body) and azimuthal direction (direction of advance of the flying body), and the correlations between the respective received signals and reference signals are found to give higher resolution than that is obtained from an ordinary radar sensor.

SAR observations are performed with a center frequency of 1275 MHz , 20 KHz, band width of 15 MHz, horizontally polarized transmission - horizontally polarized reception (H - H), off-nadir angle 35.21°, and transmission pulse width of 35 μ sec.

Also, this radar has 5 waves, with transmission pulse repeat frequencies (PRFs) of 1505.8 MHz, 1530.1 MHz, 1555.2 MHz, 1581.1 MHz and 1606.0 MHz. A scan width of 75 Km is observed; The ground surface resolution and range direction resolution, are 18m (3 looks) in the range direction and 18m in the azimuth direction.

The principal performance features of the SAR are given in Table 5-1.

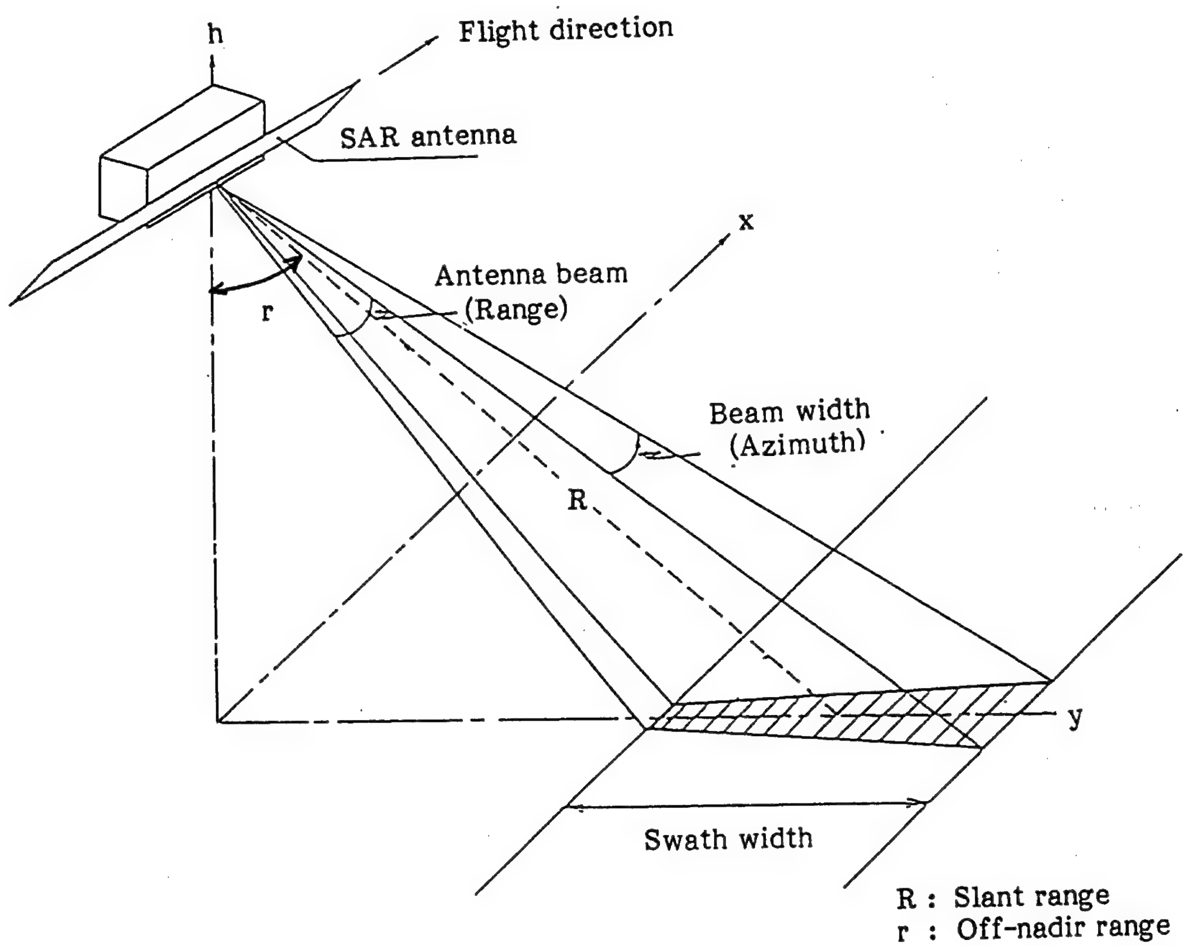


Fig. 5-1 Concept of SAR Scanning

Table. 5-1 Characteristics of SAR

Item	Performance
Center frequency	1275MHz ± 20KHz
Band width	15KHz (nominal)
Polarization	(H - H)
Off - nadir angle	35.21°
Swath width	75Km
Resolution	Range 18m max Azimuth 18m max (3 looks)
Noise equivalent backscattering coeffcient	-20.5 dB max
S / A	14 dB min,,
Power	Average of T.B.D Peak of T.B.D
Transmitted pulse width	$35 \begin{smallmatrix} +0.5 \\ -0.0 \end{smallmatrix}$ μsec
PRF	1505.8 Hz, 1530.1 Hz 1555.2 Hz, 1581.1 Hz 1606.0 Hz (nominal)
Antenna gain	33.5 dB min,,
Observed data	Quantization : 3 bit Data rate : 30 Mbps 2 ch.

5.2 Optical Sensor

The optical sensor (OPS) is an electronic scan typed optical sensor that observes in 4 bands in the visible and near infrared (VNIR) region, and in 4 bands in the short wavelength infrared (SWIR) region. As shown in Fig. 5-2, the OPS gathers light in both the flight direction and the lateral direction. The light that is gathered is split by a prism or filters, and converted to electronic signals by a 4096-element CCD sensor.

The OPS`s wavelength region for observation is divided into 8 bands, as shown in Table 5-2. Among these, VNIR`s band 4 is used for depth perception. The principal performance features of the OPS are given in Table 5-3.

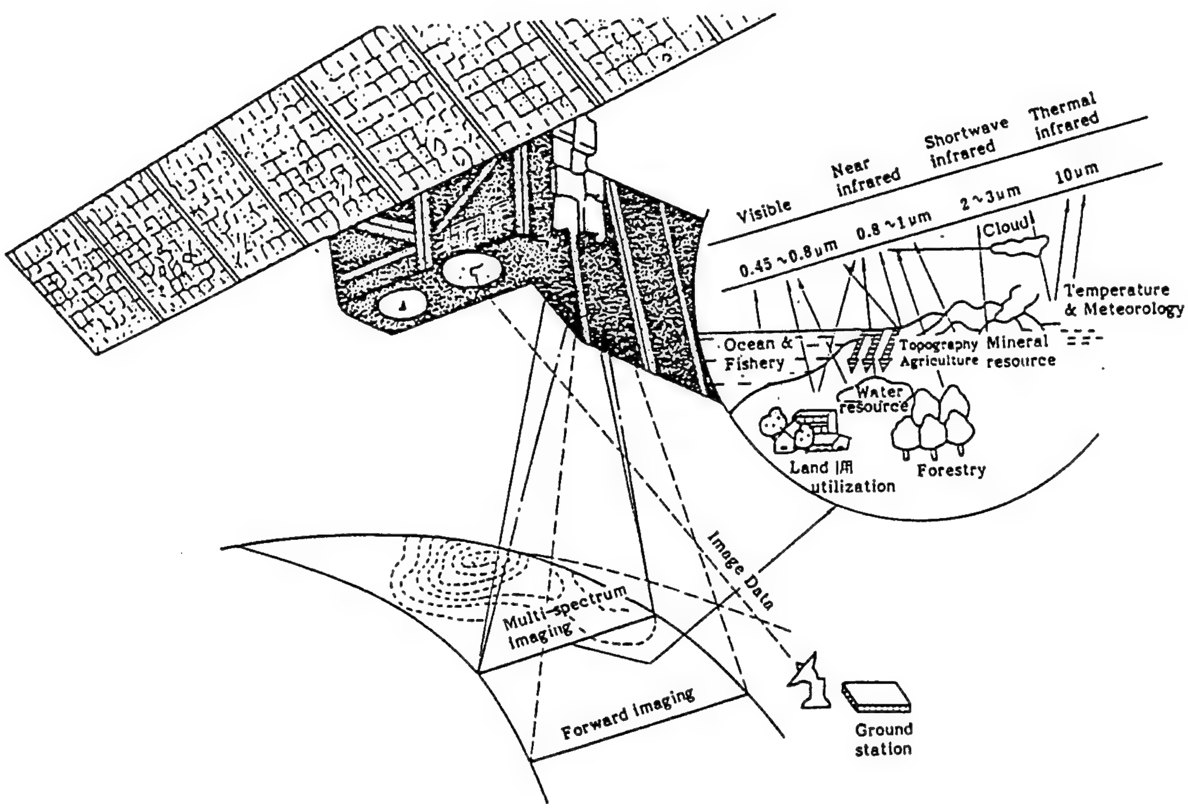


Fig. 5-2 Concept of OPS Scanning

Table. 5-2 Wavelength of OPS

Band	Center wavelength(μ m)	Band width(μ m)	-
1	0.56 ± 0.01	0.08 ± 0.02	VNIR
2	0.66 ± 〃	0.06 ± 〃	
3	0.81 ± 〃	0.10 ± 〃	
4	0.81 ± 〃	0.10 ± 〃	
5	1.655 + 0.016 - 0.015	0.11 ± 〃	SWIR
6	2.065 + 0.015 - 0.017	0.11 ± 〃	
7	2.19 + 0.015 - 0.019	0.12 + 0.02 - 0.023	
8	2.335 + 0.015 - 0.020	0.13 + 0.022 - 0.024	

Table. 5-3 Characteristics of OPS

Item	Performance
Stereo angle	15.3 ° ± 0.21 °
Swath width	75km
Resolution	Range 18.3 m
	Azimath 24.2 m
Detector	4096 CCD elements per band
Sampling cycle	3.46 msec
Output data rate	30 Mbps × 2 ch.
Quantization level	64 (6bits)
Dynamic Range	Band1 0～324 $W/m^2 \cdot str \cdot \mu m$
	〃 2 0～250 〃
	〃 3 0～248 〃
	〃 4 0～239 〃
	〃 5 0～33.3 〃
	〃 6 0～17.8 〃
	〃 7 0～13.7 〃
	〃 8 0～10.8 〃

5-3. Mission Data Transmitter

The Mission Data Transmitter (MDT) transmits data observed by the SAR and OPS and recorded in the MDR to ground.

When the observed data are recorded, the observed data from the SAR or OPS are transmited to the MDR. Also, a master clock signal of 30 MHz is generated, and supplied to the SAR, OPS and MDR. And the principal performance features in Table 5-4.

Table. 5-4 Characteristics of MDT

Item	Performance
Carrier frequency	f_1: 8.15 GHz f_2: 8.35 GHz
Power	f_1: 41.2 dBm min f_2: 41.2 dBm min
Modulation	QPSK
Bit Rate	60 MBPS
Polarization	RHCP
Band width	50 MHz max

5.4 Mission Data Recorder

The Mission Data Recorder (MDR) records observed data from the SAR and OPS, reproduces data in the ground station visible region and transmits them to the ground stations via the MDT. And the principal performance features in Table 5-5.

Table. 5-5 Characteristics of MDR

Item	Performance
Recording capacity	20 minutes min
Reproduction capacity	20 minutes min
Recorded data	Input channel 2 ch Data rate 30 Mbps / ch
Reproduced data	Output channel 2 ch Data rate 30 Mbps / ch
Bit error rate	1×10^{-6} max
Electric-power consuption	252 W max
Weight	74.7 Kg max

5.5 Operation Mode

Mission instruments are generally operated only in daytime, except for MDR reproduction. The mission instrument modes are given in Table 5-6.

Table. 5-6 Operational Mode

Mode	State of operation	Sunlight	Eclipse
A	SAR realtime observation	O	△
B	OPS realtime observation	O	×
C	VNIR realtime observation	O	△
D	SAR recording	O	×
E	OPS recording	O	×
F	reproducing	O	×
G	MDR reproducing + SAR realtime observation	O	×
H	MDR reproducing + OPS realtime observation	O	×
I	MDR reproducing + VNIR realtime observation	O	×
J	SAR realtime observation + OPS realtime observation	O	×
K	SAR realtime observation + VNIR realtime observation	O	×
L	SAR recording + OPS realtime observation	O	×
M	SAR recording + VNIR realtime observation	O	×
N	OPS recording + SAR realtime observation	O	×

6. Processed Products

After the various corrections are applied to JERS-1 observational data and processing is completed, they are reproduced on CCT, OD and film as output products. The processing levels of each sensor are given in Table 6-1 and Table 6-2. A summary of the products is given in Table 6-3 and 6-4.

Table. 6-1 Processing Level (SAR)

Level	Name	Processing method	CCT	PHOTO
0	Unprocessed Signal Data Product	Raw data and correction data.	○	
1.0	Partially Processed Signal Data Product	Range compression only (with range reference function), correspond to Real Aperture Radar.	○	
1.1	Basic Image Product	Level 1.0 plus azimuth compression with range migration correction. (3 looks or 1 look)	○	
2.0	Bulk Image Product	Level 1.1 plus σ° conversion, resampling and conversion of Slant Range to Ground Range. (X axis : Azimuth, Y axis : Range)	○	○
2.1	Standard Geocoded Image Product (Standard Product)	Level 2.0 plus resampling comsidering with map projection. (UTM and PS)	○	○
3	Precise Corrected Image Product	Level 2.1 plus precise correction using GCP.	○	○
4	Geocoded with Terrain Correction	Level 3 plus foreshortening correction using DTM.	○	○

Table.6-2 Processing Level (OPS)

Level	Name	Processing method	CCT	PHOTO
0	Unprocessed Data Product	Raw data and correction data .	○	
1	Radiometric Corrected Image Product	Radiometric correction only.	○	
2	System Corrected Image Product (Standard Product)	Level 1 plus geometric correction and map projection without band 4 . (UTM , SOM and PS)	○	○
3	Precise Corrected Image Product	Level 2 plus precise correction using GCP .	○	
4	Registration Corrected Image Product	Level 3 plus registration using RCP	○	
5	Stereo Image Product	Level 2 plus band 4 data as stereoscopic image	○	○

JERS-1 DATA AND INFORMATION SYSTEM

FOR

RESOURCES EXPLORATION

K.Yoshida

Earth Resources Satellite Data Analysis Center(ERSDAC)

1.PREFACE

The Japanese Earth Resources Satellite-1 (JERS-1) that is jointly developed by the Ministry of International Trade and Industry (MITI) and the National Space Development Agency of Japan (NASDA), will be launched in February 1992 from Tanegashima Space Center (Fig.1 JAPANESE EARTH RESOURCES SATELLITE-1). JERS-1 will carry two mission sensors. One is an L-band synthetic aperture radar called SAR (ground resolution: about 18m in both range and azimuth directions). The other is an optical sensor named OPS (ground resolution: about 18m and 24m in cross and along track directions respectively) that can measure solar radiation reflected from the earth's surface in the visible, near infrared and short wavelength infrared regions.

Having the capabilities of generating near-infrared stereocospic images during the same orbit, detecting solar radiation through multi-spectral channels in the short wavelength infrared, and performing all-weather land observation, JERS-1 has been collecting great attentions from a large number of domestic and foreign users concerning with resources exploration, forestry, fishery, agriculture management, environmental protection, etc.

The Earth Resources Satellite Data Analysis Center(ERSDAC) was established in 1981 as a non-profit organization endowed by 27 Japanese companies leading in underground resources exploitation and space industry, and is managed under MITI'supervision. The main objective of ERSDAC is to mediate between resources users, MITI and NASDA by promoting R&D activities for non-renewable resources exploration based on data provided from satellites such as LANDSAT and SPOT etc ERSDAC's R&D activirties include also image processing and analysis techniques, their applications for resources investigations through case studies and ground truth data collection. ERSDAC also promotes the global cooperation through exchange of information and technology with foreign organizations related to remote sensing. Expecting a large amount of observation data expected to get from JERS-1, ERSDAC is developing the JERS-1 DATA AND INFORMATION SYSTEM (or ERSDIS), to process them for application purposes. ERSDIS will start its service around the middle of 1992

2.SYSTEM OUTLINE

A large amount of observation data from JERS-1 will be mainly received by the Earth Observation Center of NASDA (NASDA EOC) in Japan. These image data,after basically processed and recorded on high-density magnetic media, will be sent to the Data Center of ERSDAC (ERSDAC Data Center). On the other hand, a large number of mission orders from resources users will be sent to NASDA EOC, and taken into consideration of the mission operation planning (Fig.2 JERS-1 MISSION OPERATION).

ERSDIS consists of three sub-systems (Fig.3 ERSDIS OUTSTANDING FUNCTION). Each of them has a large-scale host computer equipped with several up-to date work stations, terminals and I/O devices (Fig.4 STRUCTURE OF ERSDIS).

ERSDIS will be using high-density D-1 cassette tapes (Memory capacity:42 GB) to store data received from NASDA EOC and high-speed cellular array processors (Processing speed: several hundreds MFLOPS) for large-scale image data processing.

Transfer of informations among three sub-systems plays an important role for integration of the whole system. Optical LAN (FDDI, 100 Mbps) is used for transmission of image data, though LAN (Ethernet, 10 Mbps) is used for general code information. As each sub-system includes hardware of guite different communications protocols, such a connection will be performed in accordance with world-wide recognized OSI (Open Systems Inter-connection) standards. ERSDAC is now developing effective application softwares to realize the above functions.

3.PROCESSING AND PRODUCTS

The followings are the analysis processings of ERSDIS to be performed on JERS-1 image data from NASDA EOC.

1)Pre-processing for analysis
- Registration correction between OPS/SWIR's bands

2)Standard analysis
- Standard products manufacturing by remote ordering
- Standard products manufacturing by ERSDAC operator in Data Center

3)Advanced analysis
- DTM data computation from OPS stereoscopic data
- Superposing of SAR and OPS images

9 types of standard analysis are planned at this moment, and more will be available in future if requested (Fig.5 STANDARD ANALYSIS PRODUCTS). When ordering,users will be provided with a list of parameters for each standard analysis with a considerable numbers of alternatives, that produces effectiveness in actual use. Photo films, magnetic tapes and floppy disks are basically available as standard product media to the analysis processing (Fig.6

PRODUCT MEDIA). Mutual relationship between the above three analysis processings and their individual capabilities are determined by our consistent study (Fig.7 PROCESSING & PRODUCTS MANAGEMENT).

4.USER SERVICES

ERSDIS users with prior registration are supposed to belong to either of two following groups:visiting users and remote users. Any visiting user to ERSDAC Head Quarter or ERSDAC Data Center can access to ERSDIS through a retrieving terminal, a quick look displaying and so on, and can order any image products which he needs, by referring to sample image prints. He is able to operate one of the image analyzing work station on the reservation basis located in ERSDAC Data Center for performing his own work.

If he gets access to ERSDIS by his own terminal via a public telephone circuit, he should be a remote user. Available service menus for remote users are as follows.

1)Retrieving of image data catalogues
2)Displaying of Q/L (Quick Look) catalogues
3)Q/L facsimili service
4)Ordering of image products
5)Inquiring of processing status
6)Inquiring of mission operation information

What a remote user needs in order to get these services is a remote terminal and a FAX receiver, though service quality may differ depending on his terminal type(Fig.8 SERVICE CAPABILITY BY USER'S MACHINES). Basic screen transition in remote terminal corresponds to the above service menus (Fig.9 SCREEN TRANSITION IN REMOTE TERMINAL).

5.CONCLUSION

ERSDIS is being developed under supervision of MITI and with collaboration of related orgarnizations. Actual operation of ERSDIS will start probably around the middle of 1992, after JERS-1 is in post-launch check and verification period that will last for several months. International users are acceptable according to conditions to be determined in near future.

JERS-1 data distribution policy is going to be decided before start of ERSDIS actual operation. ERSDIS function would be improved and enhanced successively based on user requests after actual operation to establish a better system in future.

ERSDAC

Main Characteristics

Shape	Structure Box type Approx. 1m×1.8m×3.1m Synthetic aperture radar Approx. 12m×2.5m Solar cell paddle Approx. 8m×3.4m	
Weight	Approx. 1.4 t	
Attitude control	Three-axis stabilized (zero momentum)	
Design life	2 years	
Launch vehicle	H–I (2-stage)	
Launch site	Tanegashima Space Center, Kagoshima	
Launch date	Winter, 1992	
Orbit	Type	Sun synchronous subrecurrent orbit
	Altitude	Approx. 570km
	Inclination	Approx. 98 deg.
	Period	Approx. 96 min.
	Recurrent period	44 days
	Local time at Descending node A.M.10:30~11:00	

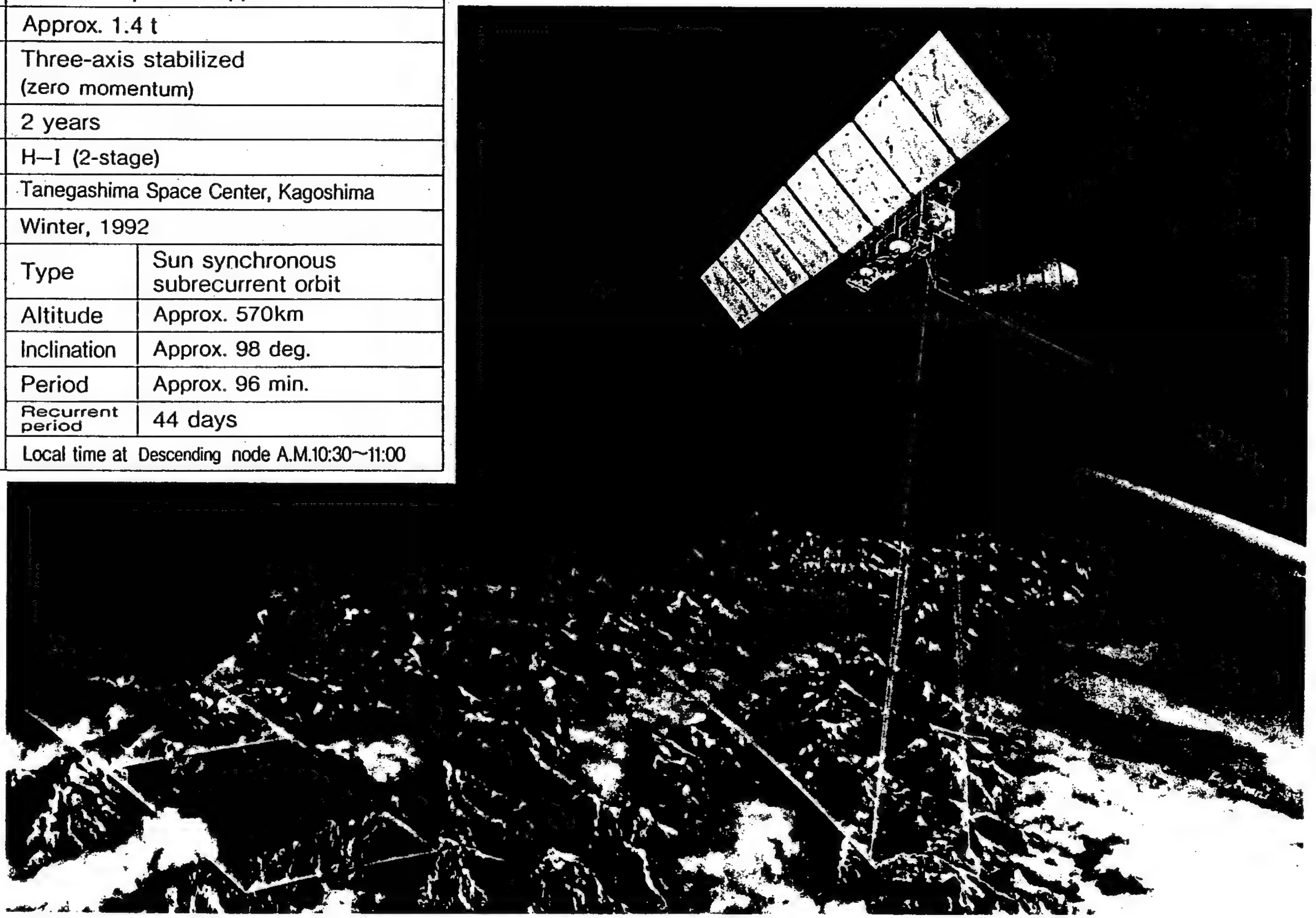


Fig. 1 JAPANESE EARTH RESOURCES SATELLITE-1

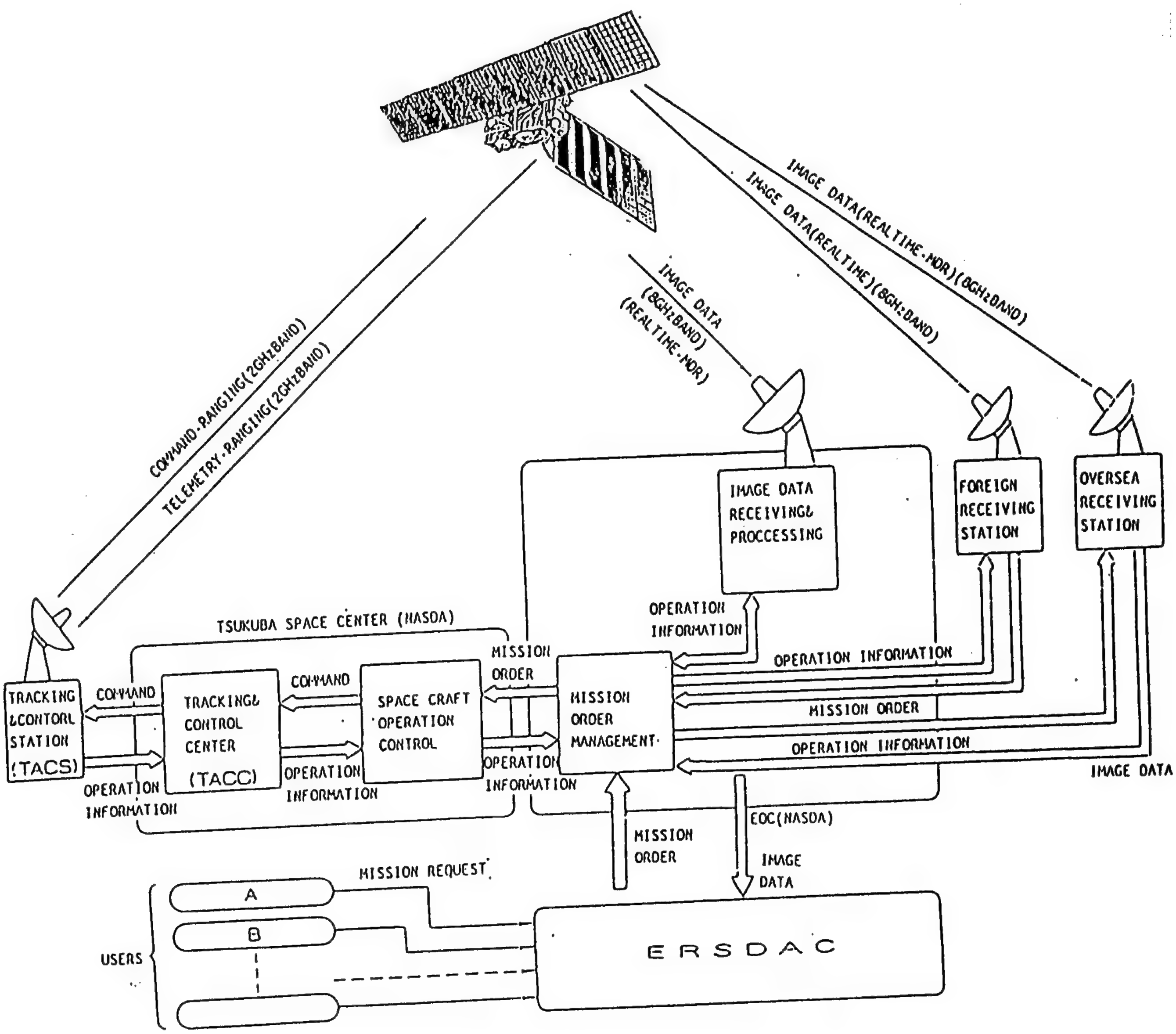


Fig. 2 JERS-1 MISSION OPERATION

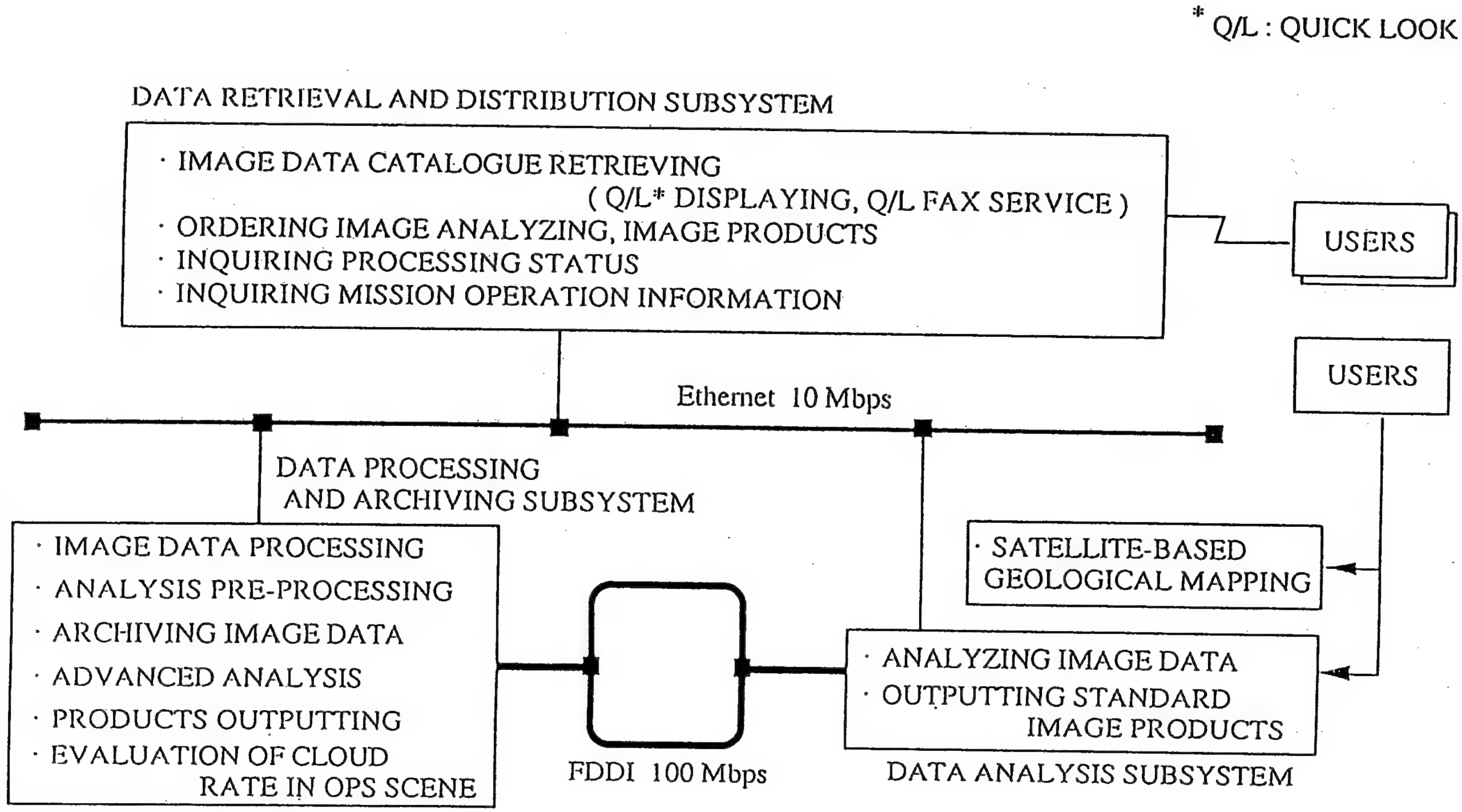


Fig. 3 ERSDIS OUTSTANDING FUNCTION

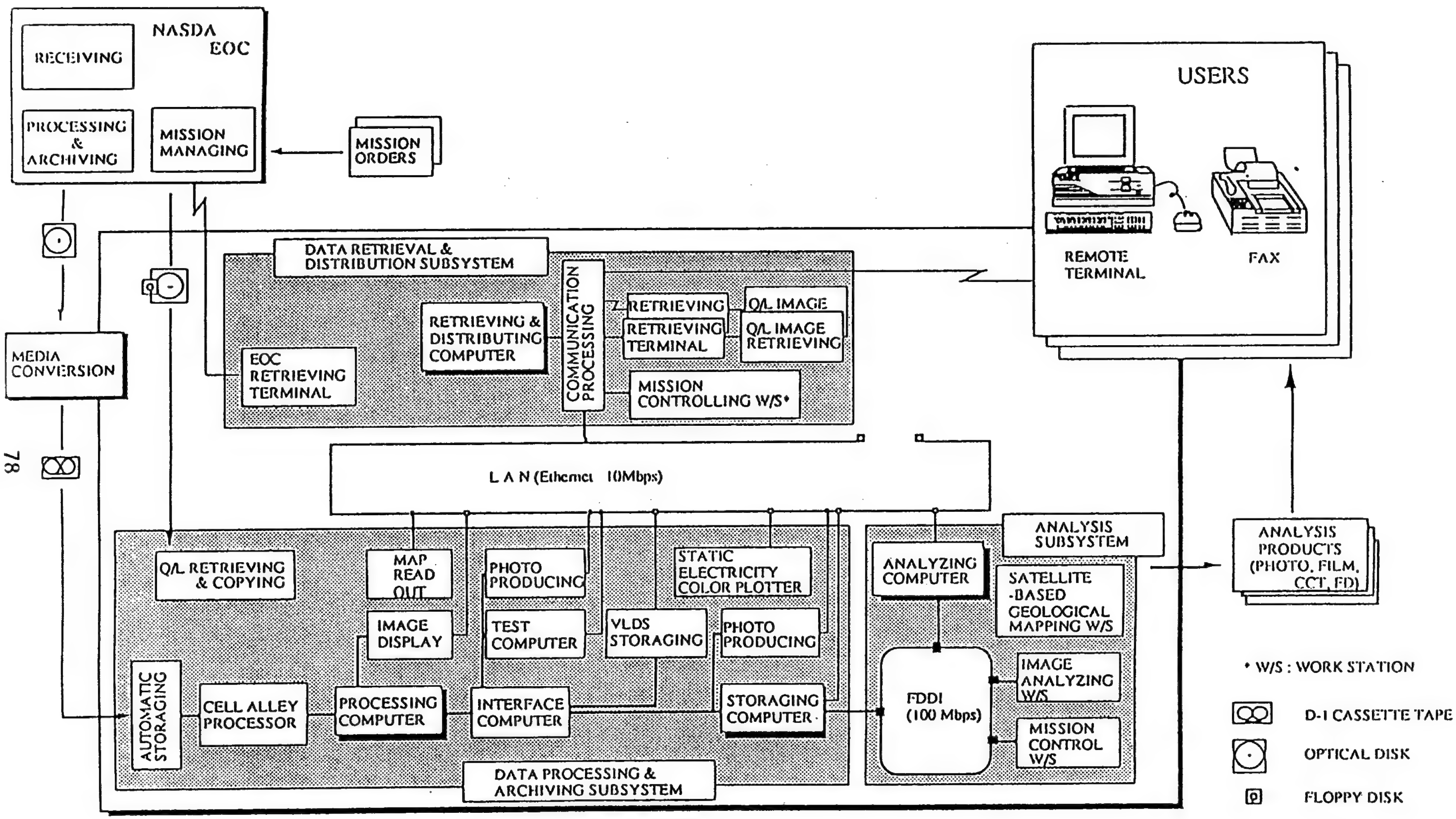
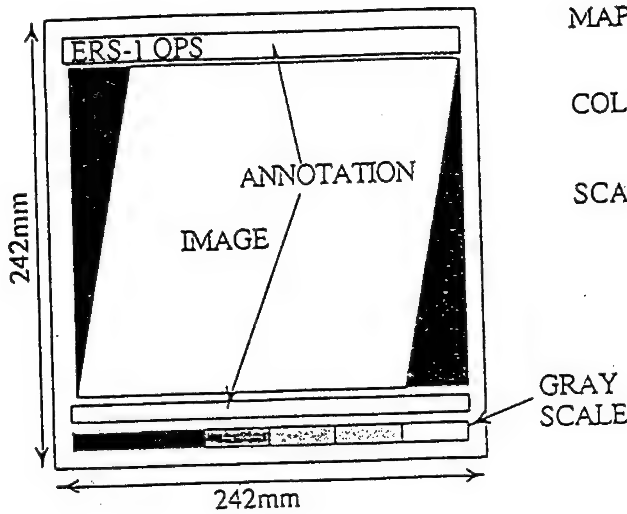


Fig. 4 STRUCTURE OF ERSDIS

SENSOR	PRODUCT ITEM
OPS	· COLOR COMPOSITE IMAGE · TEXTURE ANALYSIS IMAGE · CLUSTERING IMAGE · RATIOING IMAGE · HSI MODULATION IMAGE · PRINCIPAL COMPONENT ANALYSIS IMAGE · DE-CORRELATED STRETCH IMAGE · DRAINAGE PATTERN RECOGNITION IMAGE
SAR	TEXTURE ANALYSIS IMAGE

Fig.5 STANDARD ANALYSIS PRODUCTS

PRODUCT MEDIA (PHOTO, FILM)

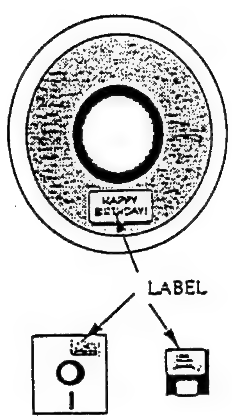


MAP PROJECTION : UTM

COLOR : FULL COLLOR / MONOCHROME

SCALE : SIMILAR TO 1/500,000
(STANDARD TYPE)

PRODUCT MEDIA (MAGNETIC MEDIA)



MAGNETIC TAPE ..... CCT 2400 FEET, 6250 BPI

FLOPPY DISK ..... 5 INCHES OR 3.5 INCHES (2HD)
MS-DOS FORMAT

DATA RECORD TYPE ..... SAR : BASED ON CEOS
OPS : BASED ON TM

Fig. 6 PRODUCT MEDIA

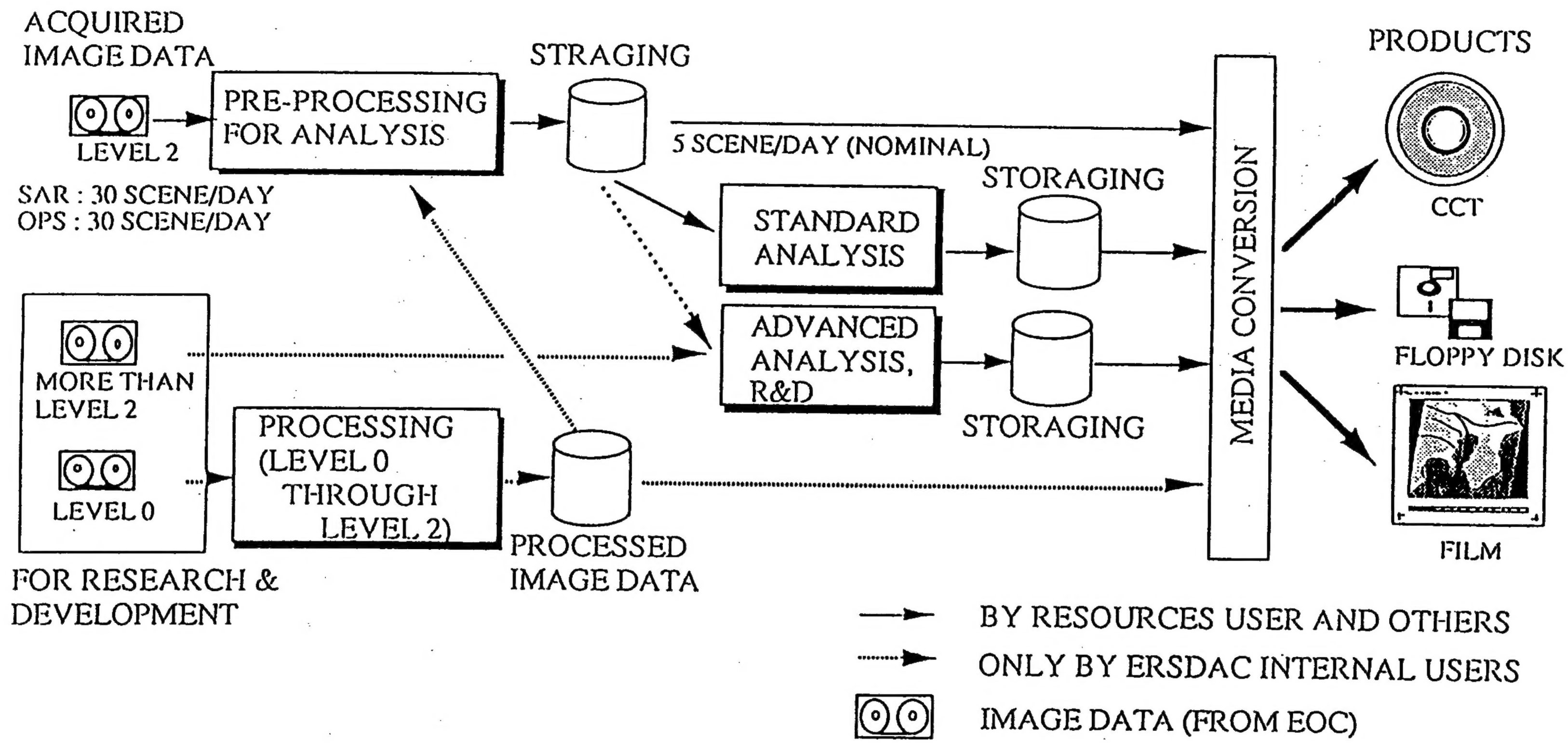


Fig. 7 PROCESSING & PRODUCTS MANAGEMENT

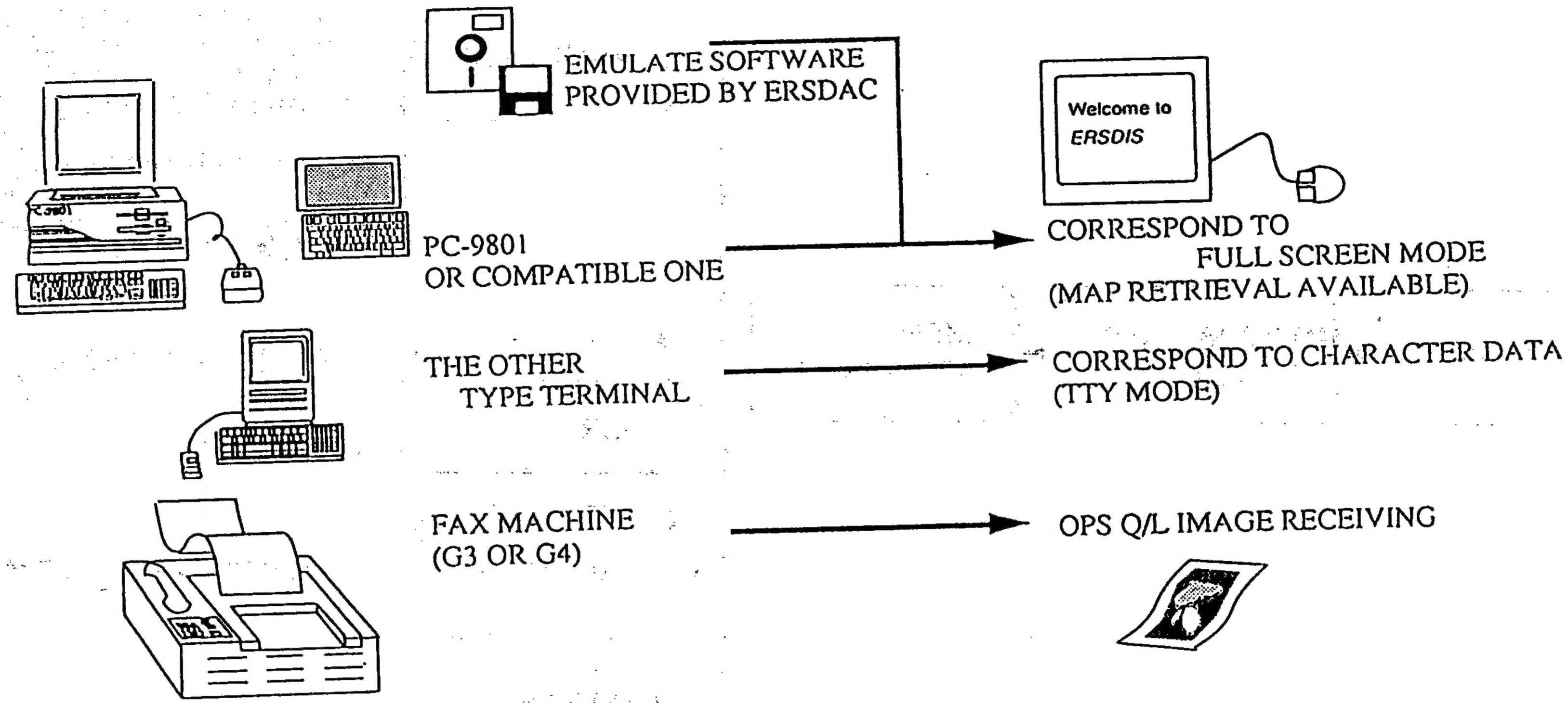


Fig.8 SERVICE CAPABILITY BY USER'S MACHINES

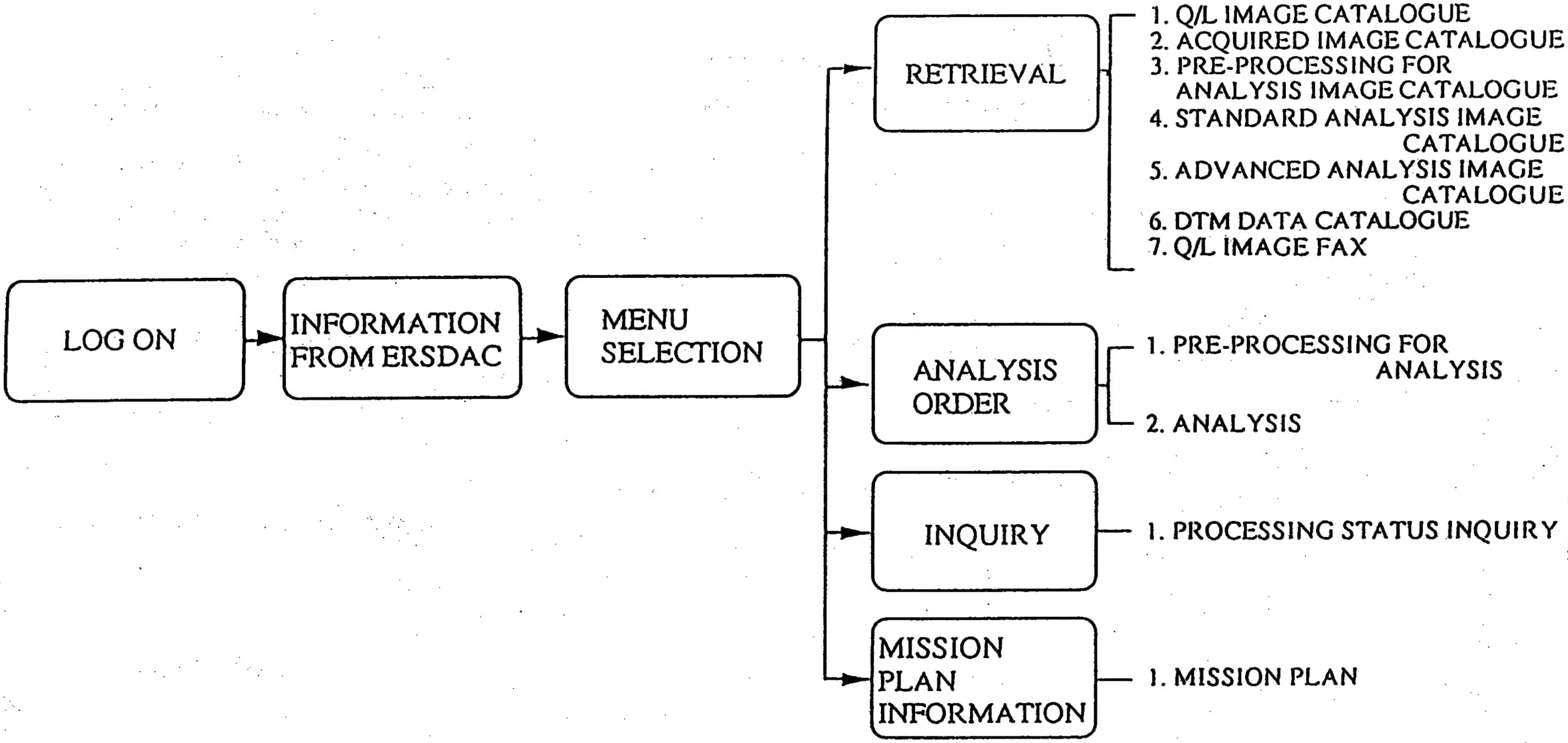


Fig. 9 SCREEN TRANSITION IN REMOTE TERMINAL

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